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NEW YORK UNDERGROUND RAPID TRANSIT railway affairs have progressed favorably since our last issue. On Feb. 16 the Appellate Division of the Supreme Court granted the modifications in the contract which were asked for by August Belmont & Co. These modifications were that the sureties be released from the necessity of qualifying in twice the amount of bonds required, only qualifying in the actual sum called for, and also that the minimum amount required from the surety companies be reduced from $500,000 to $250,000. The four surety companies that are to take up the $1,000,000 of the $5,000,000 construction bond will therefore qualify in $250,000 each. The remaining sums will be furnished by the Belmont syndicate and the contractor on the lines indicated in our issue of Feb. 15. The next task to be accomplished before the contract can be signed is to organize officially the proposed construction company, and August Belmont & Co. have asked the Rapid Transit Commission for a further delay of ten days in which to do this. This extension will undoubtedly be granted.

THE GENERAL TRAMWAY CO., OF PARIS, says "Le Genie Civil," in an article on the transportation facilities of Paris and its suburbs, in 1898 transported 28,788,547 passengers; or about 78,872 per day, or an average of 744 per day per horse car. The average receipts per passenger were 3 cts., and the cars made a total run of 2,656,709 miles. The expenses of operation amounted to 27.3 cts. per car-mile; though it should be said that this cost was largely increased by the fact that the lines are being changed from horse-traction to electricity.

THE BRIDGE ACROSS SYDNEY HARBOR, for which competitive plans are asked by the New South Wales Government, as briefly noted in our issue of Jan. 18, 1900, will be of unusual magnitude, according to a press notice which has recently been received, from Sydney. Respecting the proposed bridge this notice says:

> Such a structure has become a pressing necessity, but although its importance has been recognized by successive ministries, that of which Mr. Lyne is the head has been the first to take practical action in the matter by offering a couple of prizes, one of £1,000, and another of £500, open to all the world, for the most suitable designs for the required bridge. The designs must provide for two footways each 10 ft. wide, two roadways each 20 ft. wide, or one roadway 40 ft. wide, also for a width of 24 ft. in the clear for a double line of railway. It is considered that the bridge should be a single tier bridge, as the extra height to be surmounted by the railway or road, as the case may be, might be an objection, but designs showing either the footways or the roadway, or both, overhead, may be submitted, and will receive consideration. The bridge must consist of a single span, and a clear headway of 180 ft. above high water, for at least the middle 600 ft. of its length, must be provided. The structure must be designed to carry a live load of 130 lbs. per superficial foot of roadway and footpath, and every part of the roadway is to be capable of carrying a moving load of 30 tons on two pairs of wheels, and for a train on each line of railway consisting of three of the heaviest class of engine and tender in steam, followed by loaded trucks. The engines and tenders are to be taken as weighing 110 tons, with a length of 55 ft.; and an axle load on drivers of 18 tons, the distributed load due to the loaded trucks to be taken as 1½ tons per lin. ft. The competitive designs will have to be delivered in Sydney not later than Aug. 1, 1900.

A COMMERCIAL COMMISSION TO CHINA AND JAPAN is the subject of a bill, agreed to by a sub-committee of the U. S. Senate, authorizing the President to appoint such a commission of five persons. The members are to be selected one each from the Eastern, Middle, Southern, Western and Pacific Coast states; they are to study especially the industrial conditions of China and report upon the opportunities for the enlargement of American trade in raw products and manufactured goods. They are also to ascertain what products of our farms, mills and workshops may be sold there, and how they should be packed, shipped, paid for, etc. The commission is also to visit and report upon in a similar manner, Japan and adjacent countries in Eastern Asia. The bill appropriates $75,000 to pay for this work. It is objected that the commission is unnecessarily large, and its geographical distribution makes it more difficult to select the proper kind of men and to remove this selection out of the domain of politics. According to the New York "Journal of Commerce," one man now very active in trying to obtain a place on this commission, on the strength of a brief visit to China in a subordinate commercial capacity, is just the type of investigator least likely to be useful to American trade in China and the East.

AMERICAN COMMERCE IN THE PACIFIC, says the U. S. Bureau of Statistics, has increased, in 1899, by $20,000,000 in exports alone; of the total increase of $164,000,000 in the year, $48,000,000 were from Asia and Oceania. In other words, exports to the latter points increased 27%, and imports 48%. Of the exports, over $6,000,000 went to British Australia; $4,000,000 to the Hawaiian Islands, and $4,000,000 to China. Of the imports, $12,000,000 came from the Dutch East Indies; $11,000,000 from Japan; $9,000,000 from the British East Indies; $7,000,000 from China, and $6,000,000 from Hawaii. The large proportion of the increase in exports was in cotton, cotton goods, machinery and other manufactures of iron and steel. The bulk of the imports was made up of raw silk, tin, fibers, and sugar.

A SHIPBUILDING PLANT, with a capital of $17,000,000, is rumored as being in process of formation in New York; and the names mentioned in this connection are those of the Cullen Bros. and Lewis Steel Co., the Troy Steel Co. and Witherbee, Sherman & Co., of Mineville, N. Y. Under this consolidation the new company would control the steel works at Troy and Albany, with an annual capacity of 200,000 tons of ingots, and 200,000 tons of rolled material, and the 11,000 acres of iron ore land at Port Henry and Mineville, with an annual average output of 500,000 tons of ore. The shipyards are not definitely located, but would probably be on the North River.

THE CHICAGO DRAINAGE CANAL showed its effect upon the navigation of the Chicago River Feb. 16, the current causing an accident to the steamer "Jesse Spalding." The current was estimated to be at the rate of 1½ to 2½ miles per hour, and the flow amounted to 320,000 cu. ft. per minute (285,000 cu. ft. going over the dam at Lockport and 35,000 cu. ft. into the Illinois and Michigan Canal at Bridgeport). The steamer was lying in a slip at Morgan St., where the river is 140 ft. wide and 22 ft. deep. As the bow emerged from the slip the force of the current swung it upstream, in spite of the efforts of the tug, while a rope hitched to the dock was at once broken. The steamer swung until the bow caught against a dock on the opposite side of the river, and as the stern was still within the slip the vessel formed a dam reaching to within 7 ft. of the bottom of the river. Attempts to pull it off by tugs only resulted in breaking the ropes. The Drainage Board was notified, and orders were telegraphed to Lockport to raise the dam and check the current, the effect of which was not felt at Morgan St. for some hours. The steamer is 200 ft. long, and was loaded with 70,000 bushels of corn, giving a draft of 15 ft. Mr. Randolph, the Chief Engineer of the canal, is reported as saying that it will be necessary to dredge out the slips, while Mr. Carter, one of the trustees, advocates flaring out the entrances to the slips, so that vessels coming out can have more room in which to swing as they enter or leave the slips.

THE LAKE ERIE & OHIO RIVER SHIP CANAL is before the U. S. Senate and House of Representatives for incorporation and establishment as a military post road. Starting at Pittsburg, the canal would pass via the Ohio, Beaver and Mahoning rivers to Niles, O., and thence to Lake Erie; with branches to Greenville, Pa., and to Warren, O. The canal would be at least 15 ft. deep and have a cross section not less than 2,000 sq. ft. in area. The locks would be 340 ft. long by 45 ft. wide in the clear, with 15 ft. of water on miter-sill. Between the Ohio River and Lake Erie the lockage shall not exceed 600 ft. The capital stock of the company is not to exceed $300,000 per mile of canal, and bonds and other indebtedness not more than $300,000 per mile. The United States may at any time assume possession of the canal by paying the value of the same as fixed by three arbitrators with nothing allowed for the value of the franchise.

VOLCANIC DISTURBANCE ON THE LINE of the proposed Nicaragua Canal is feared by Prof. Angelo Heilprin, of the University of Pennsylvania. In a letter published in the New York "Evening Post," he goes minutely into the known seismic disturbances in Nicaragua and the adjoining states, from 1717 to 1888, and, after discussing the favorable reports of other experts, he concludes that it is not safe to assume, with them, that these volcanoes represent some final geological period and are so reduced in activity that they may be disregarded by the canal builders. He presents a fair case, but admits that it is impossible to foretell the effects of such action upon construction, or the recurrence of such action. Prof. Heilprin would prefer the Panama route, whatever else may be its deficiencies, for the reasons stated. He compares the eruption of Cosequina, in 1835, and only 150 miles from the proposed canal, to that of Krakatoa, in 1883, in its violence and wide disturbance.

AN OCEAN DEPTH OF 5,260 FATHOMS, or 31,560 ft. has been found by the U. S. S. "Nero," which has lately been engaged in making soundings for a submarine cable between Guam and Manila. In November, 1899, the "Nero" reported a sounding of 4,900 fathoms about 500 miles east of Guam. The deepest ocean sounding heretofore reported was 30,930 ft., northeast of New Zealand and east of the Kermadecs, in the South Pacific.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the derailment of a passenger train by a washout on the Boston & Maine R. R., near Quinapaxet, Mass. The locomotive and combination baggage and smoking car were totally wrecked and five trainmen were seriously injured.

A LOCOMOTIVE BOILER EXPLODED in the roundhouse of the Atchison, Topeka & Santa Fe Ry. at Topeka, Kan., on Feb. 16, killing two men and seriously injuring three others.

A LOCOMOTIVE WITH MARINE BOILER is being tried experimentally on the Atchison, Topeka & Santa Fe Ry. The engine is of the consolidation type. The boiler is 17 ft. 1 in. long and 6 ft. 4½ ins. diameter, and in front of its combustion chamber is a casing (like the ordinary smokebox shell) for the exhaust and steam pipes. The corrugated furnace is 14 ft. 3 ins. long and 3 ft. 4 ins. diameter, with a grate 6 ft. 9 ins. long. Air is supplied under the grate by a pipe leading along the bottom of the furnace flue to the combustion chamber, where it opens to the air and is fitted with a damper. The products of combustion pass through the furnace to the combustion chamber, then back through 133 tubes to a chamber in the cab, and then return through two flues on either side of the top of the boiler to a chamber carrying the smokestack. The exhaust nozzle is extended up to this chamber. There is an ashdoor in the furnace head directly over a hopper-shaped ashpan. Circulating pipes have had to be fitted to enable steam to be raised promptly, but the steaming capacity is said to be ample for such experimental work as the engine has so far had. The design was suggested to Mr. Player, Superintendent of Machinery, by the late Mr. C. M. Higginson, Assistant to the President of the A., T. & S. F. Ry. The engine has been fitted up at the shops of the company at Topeka, Kan., and is now undergoing tests as to its performance.

THE RUSSIAN TRANS-PERSIAN RAILWAY is said to be decided upon at St. Petersburg. It would be 1,300 miles long and cost 150,000,000 roubles; with a line paralleling the western boundary of Persia, and commencing at Dsulfa, near the Trans-Caucasian border, and passing by way of Tabreez, Hamadan, Ispahan and Kerman, to Bander Abbas on the Persian Gulf.

A TRANS-SAHARA RAILWAY COMMISSION has left France for Algiers to inspect a route proposed from Algiers to the Nile Valley. The claim is made that such a railway is imperatively necessary for France as a military measure, and to connect her scattered territory in Africa.

JERSEY CITY VOTED TO BUY ITS NEW WATER supply works on Feb. 13, by 3,964 votes for to 576 against the proposition, out of a total registration of nearly 28,000 voters. This means that $7,595,000 will be paid for the works now being built under the contract with Mr. Patrick H. Flynn to supply the city with 50,000,000 gallons a day. The supply will come from the Rockaway River, by gravity. Comparatively little work has been done under the contract.

THE PAVING BRICK TESTS of the Brick Manufacturers' Association have been materially changed. The standard tests adopted by the association provided for a rattler test of bricks alone, as distinguished from the Talbot or University of Illinois system, in which cast-iron "shot" or blocks are put in the rattler with the bricks. The association has now, on the recommendation of a special committee, composed of manufacturers and engineers, adopted the latter system as giving more reliable and more satisfactory results. Further investigations are to be made as to the Jones system, in which the bricks to be tested are fastened to the inner circumference of the rattler. This test has both favorable and objectionable features, but is considered worthy of further trial.

## TRACK ELEVATION IN CHICAGO.*

II.

### Chicago & Northwestern Ry.

In regard to the description of the raising of the Chicago River bridge at Deering, to conform to the new grade of the elevated tracks, as described in our issue of Jan. 11, it should be explained that the method of executing this work was planned by and the work executed under the supervision of Mr. Louis H. Evans, the Engineer of Track Elevation. The design for the lifting drum and approach spans was made by Mr. Wm. Graham, but revised by Mr. J. W. Schaub, who supervised the lifting of the draw span. Mr. Emil Gerber was also present during the work as the representative of the Lassig Bridge & Iron Works, the contractors for the iron work. Lydon & Drews furnished the scows and apparatus used in raising the bridge. The total length of track elevated on this road, including main, side and yard tracks, aggregates 68.68 miles.

### Chicago & Western Indiana R. R.

In addition to the description of the work on this road, as given in our issue of Jan. 11, it should be noted that the work will include the elevation of very extensive freight yards north of 46th St., between the tracks of the C. & W. I. R. R. and the P., Ft. W. & C. Ry. This will be very expensive, and will involve the longest street subways on the whole track elevation system. In one case, there are over 100 freight tracks across the streets, besides the main tracks of the two roads.

### Chicago Junction Ry.

This railway, which now owns the tracks formerly belonging to the Union Stock Yards & Transit Co., has a double track line extending east from the Stock Yards to the lake along 40th St. The tracks are on the street level, but have been depressed for about a block in order to pass under the elevated tracks of the C., R. I. & P. Ry. and L. S. & M. S. Ry. The ordinance of May 22, 1899, which has been referred to more fully in connection with the Atchison, Topeka & Santa Fe Ry., also includes some tracks of the Chicago Junction Ry. at the approaches from the elevated main line of the Chicago & Western Indiana Ry. from Wallace St. along the south side of 49th St. to the stock yards. Mr. J. B. Cox is Chief Engineer of the Chicago Junction Ry.

### Chicago, Milwaukee & St. Paul Ry.

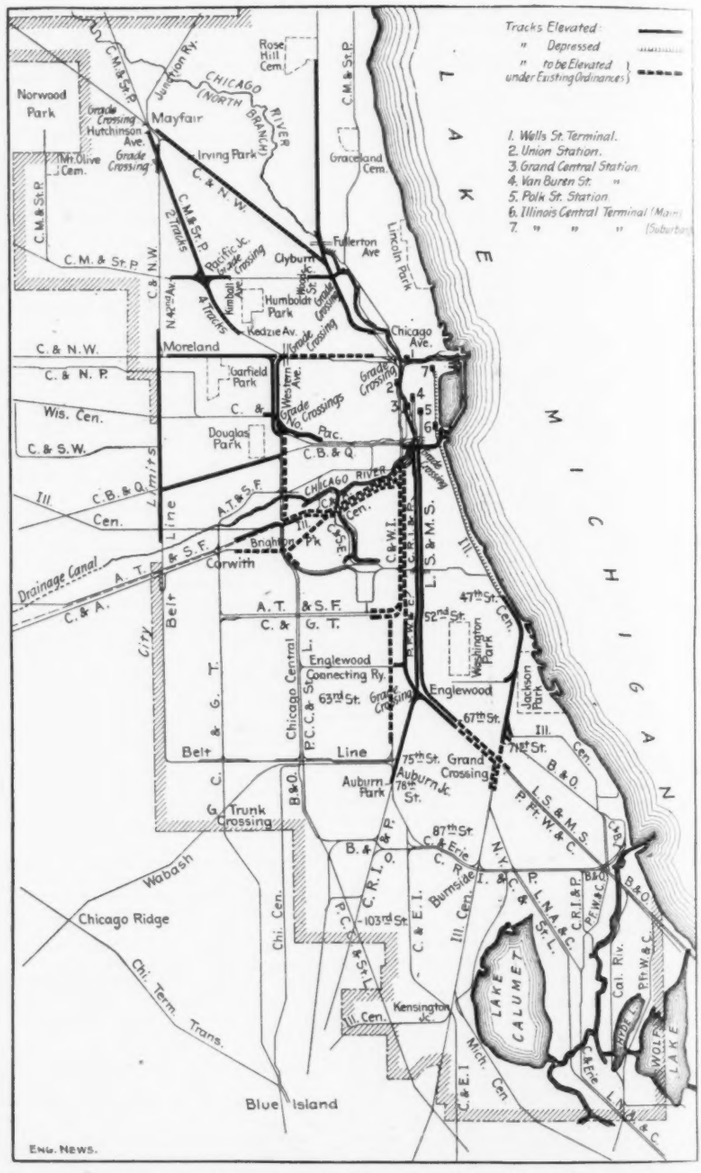
The ordinance for track elevation on the C., M. & St. P. Ry. was passed in February, 1898, and work was begun in March, surveys having already been made, but no plans prepared prior to the passage of the ordinance.

The Chicago Division has been elevated from Kedzie Ave. to Hutchinson St., half a mile north of Irving Park Ave., a distance of 4.8 miles, with 12.2 miles of single track. There are four tracks for 7,100 ft., and two tracks beyond. The Chicago & Council Bluffs Division crosses this line at Pacific Junction. The grade crossing is maintained and the C. & C. B. Division is elevated for about half a mile on each side of the crossing. There is a "Y" in each angle of the crossing, all of which are elevated. This work included the elevation of the complicated crossing and connections, with its interlocking system, at Pacific Junction, as described in Engineering News (May 11, 1899). The Chicago Division also crosses the Chicago & Northwestern Ry. at Irving Park Ave., and the grade crossing is maintained, the C. & N. W. Ry. being elevated. On the Chicago Division there are 19 subways, and 20 grade crossings were eliminated.

On the Chicago & Council Bluffs Division there are three subways, and four grade crossings have been eliminated. On this division the grade crossing of the C. & N. W. Ry., near Elston Ave. and Bloomingdale Road, is maintained, necessitating the elevation of 0.75 mile of the C. & C. B. Division. On this stretch there are two full size subways, one for pedestrians, and a new railway bridge across the North Branch of the Chicago River.

About 0.25 mile of the Deering Line at the C. & N. W. Ry. crossing, near Deering Station, was depressed. This depression and the elevation of the C. & N. W. Ry. tracks eliminated a grade crossing of the tracks at that point. The extension of the work from Hawthorn Ave. to Wood St. and From Kimball Ave. to N. 42d St., aggregate 1.6 miles in length, with 4.1 miles of single track. Seven grade crossings are eliminated, and replaced by five subways.

*The first article was published in our issue of Jan. 11, and described the general scheme, as well as the details of work on the Atchison, Topeka & Santa Fe Ry., Chicago & Northwestern Ry., Chicago & Western Indiana R. R., and Chicago, Burlington & Quincy R. R. The same number also contained an editorial on the Chicago track elevation work.




MAP OF CHICAGO RAILWAY TERMINAL SYSTEM, SHOWING LINES ELEVATED AND DEPRESSED.

During 1898 the track elevation covered 3.25 miles of road, of which two miles were four track, 0.75 mile double track, and 0.50 mile was single track, making ten miles of track eliminated in that year. During 1899 four miles of double track road, or eight miles of track were elevated, and 0.25 mile of double track road, or half a mile of track was depressed. About 300,000 cu. yds. of sand were unloaded in 1898, and about 200,000 cu. yds. in 1899. The material excavated from subways amounted to about 50,000 cu. yds. each year, making the total amount of embankment for both years 600,000 cu. yds. The average height of elevation is 10 ft.

The subways are spanned by 24 steel bridges, 14 with double track, nine with four tracks, and one with five tracks. All these have concrete abutments. There is also one three-track plate girder bridge over the foot passageway. During the process of elevation, the tracks were carried across the streets, at which the subways were to be located, on timber bridges. This plan was selected for several reasons. During the first year's elevation it was impracticable to divert the traffic from the tracks to be raised. This traffic consisted practically of all the traffic of the system which enters Chicago. It was therefore necessary to keep two of the tracks in such condition that it would be possible to operate trains over them at a fair rate of speed. The use of timber bridges permitted quick changes of grade of any amount by simply jacking up the floor and substituting longer posts.

The use of piles permitted the excavation of the roadway before the erection of the girders, thus causing a minimum delay to street traffic. It was necessary to begin work before the steel bridges could be obtained, during the first season, and

the use of timber falsework made this possible. In addition to this it was considered to be the cheapest and safest plan.

The trestles were about 800 ft. apart. Piles were driven to the level of the old grade to support the four-post bents. During 1898, the track to be elevated was raised 3 or 4 ft. by jacks and supported on heaps of sand or on stakes while sand was filled in by hand, from cars on the adjoining track. The trestles were built to the temporary height of the track, by means of caps and stringers, the track connected up and the sand trains run across. The adjoining track was then raised as high as possible without interfering with the other tracks, and these processes were continued until all the tracks had been raised to the desired height. The trestles were raised about 4 ft. at first by putting double caps, stringers and ties on the piles. For the second raise of 3 to 5 ft., the caps were raised by jacks until posts of the required height could be put in. Finally, the floor was raised to the level of the permanent grade and the posts were replaced by higher ones. The cost of unloading material, erection, and raising and removing the trestles was $2.10 per lin. ft. of track, according to the description of this work given by Mr. W. A. Rogers, Engineer of Subways, C., M. & St. P. Ry. (Journal of Western Society of Engineers, October, 1898).

When the temporary bridges were sufficiently elevated, the street excavations were commenced, so as to have all the material available for filling. The excavation being completed, the concrete piers and abutments were put in, but changes in sewers and water mains were not made until after the removal of the trestles. To prevent the drifting of the sand, the banks have been covered with 12 ins. of earth.

On the four track section, two tracks were given up to construction work, but elsewhere the sand trains had to be unloaded while standing on the main track. The rearrangement of tracks at Pacific Junction, and the delay caused by having to keep out of the way of regular trains, greatly increased the cost of the work at this point, the cost of unloading sand varying from 4½ cts. per cu. yd., under favorable conditions, to 7¾ cts. under unfavorable conditions. The traffic during the six months work in 1898 aggregated 10,000 passenger trains and 10,700 freight trains, the latter having 440,000 cars. The average was 118 trains per day, of which 60 passed during working hours, or an average of a train every ten minutes.

As a result of this experience, and its cost, two temporary tracks were built for extending the elevation northwest on the double track line from Pacific Junction to Grayland. These tracks were used for traffic while the main tracks were being raised. On this line, also, the pile foundations for the temporary trestles and the footings for the concrete abutments for permanent bridges were built in 1898, leaving the elevation work to be done in 1899.

The abutments are all of monolithic concrete. The footings are composed of 1 part Milwaukee or Louisville cement to 2 parts gravel and 3½ parts of 2½-in. crusher run limestone. The rest of the work is composed of 1 part Portland cement to 3 parts gravel and 4 to 4½ parts of stone. The gravel contains 66⅔% of coarse sharp sand and 33⅓% of small stones. The street side is faced with a mortar of 1 part cement and 2 parts sand. This facing is 1½ ins. thick, and is carried up with the regular concrete. The concrete was made in a Ransome concrete mixer, a rotary machine having a drum resting on roller bearings under its circumference. The materials were dumped in at the center of the drum, and when sufficiently mixed, movable blades were extended across the inner face of the circumference of the drum, carrying the concrete up until it dropped by gravity into a chute projecting into the central opening, but on the other side from that on which the materials were charged. It was driven by a Fairbanks, Morse & Co.'s gasoline engine of 12 HP., and could make 70 to 100 cu. yds. per day of 10 hours, with a crew of 26 to 30 men. The cost of the Milwaukee and the Portland cement concrete was $2.40 and $4.81, respectively, the latter including the erection and removal of forms. Fig. 8 shows the concrete abutments and concrete foundations for the steel columns at the curb.

The plate girders are of open-hearth steel. They were delivered on flat cars, and swung into place by two 20-ton derricks. Each derrick consisted of a flat car having a hand hoisting gear at the rear end and a steel tower and boom at the front end, the boom having a vertical reach of 22 ft. and a horizontal reach of 16 ft. The floors were then put in by the derricks for two tracks, and these bridges were then used for traffic. For wide crossings, the girders are supported by columns on the curb line. The girders and tracks are 13 ft. c. to c. The floor system consists of 12-in. 45-lb. I-beams, 15 ins. c. to c., resting on the bottom chords of the girders, and covered with a decking of 5-16-in. plates 5 ft. wide, running transversely of the bridge. Each rail rests on a ¼-in. steel plate on a pine or oak cushion 1⅜ ins. thick. This cushion is beveled to fit a special 10-in. channel, with flanges about 3⅜ ins. high. The rail is secured by clamps and ⅞-in. U-bolts, the vertical legs of the bolts passing through the wooden cushion, channel and deck plates, and having a grooved saddle piece between the horizontal leg and the under side of the deck plating. This is shown in Fig. 9.

The work of elevating the tracks, building the masonry for the subways, and erecting the steel bridges, was done by the railway company's employees. The Lassig Bridge & Iron Works, of Chicago, had the contract for the material for the steel bridges. The bridges, and the derricks used in their erection, were designed by the railway company's bridge and building department, under the direction of Mr. Onward Bates, M. Am. Soc. C. E., Engineer and Superintendent of Bridges and Buildings. The work was in charge of Mr. W. L. Webb, Engineer of Track Elevation, and the bridges were built under the direction of Mr. W. A. Rogers, Engineer of Subways. Mr. Don. J. Whittemore, M. Am. Soc. C. E., is Chief Engineer.

The cost of the work from Central Park Boulevard to Pacific Junction was $242,000. The estimated cost of the remainder of the work, from Pacific Junction to Mayfair (Kimball Ave. to N. 42d St.), and from Hawthorne Ave. to Wood St., is $389,960. This makes a total of $631,960.

### Chicago, Rock Island & Pacific Ry. and Lake Shore & Michigan Southern Ry.

These two roads are parallel and on the same 100-ft. right of way from the Van Buren St. terminal to 63d St. (Englewood), and when the track elevation ordinance was accepted in 1894, a special independent department was organized, in charge of Mr. L. H. Clarke, as Engineer of Track Elevation. In 1899 he was succeeded by Mr. M. H. Dey, who, however, no longer holds the position. The track elevation has passed the point at which the two lines diverge, and the work is carried on directly by the engineering department of each road; Mr. W. E. Dauchy is Chief Engineer of the C., R. I. & P. Ry.; and Mr. E. A. Handy, M. Am. Soc. C. E., is Chief Engineer of the L. S. & M. S. Ry.

The full elevation commences at the 16th St. crossing and extends south for 5.5 miles to Englewood, where the roads separate. Beyond this the C., R. I. & P. Ry. is elevated 1.8 miles, to Auburn Park, and the L. S. & M. S. Ry. 0.9 mile. The average height of elevation is 10 ft., and the streets are crossed by plate girder through bridges resting on abutments of cut stone or concrete. The retaining walls are of first class rubble masonry. The line is mainly four track, but there are numerous sidings, and the length of single track elevated aggregates about 70 miles. The elevation extends the full width of the right of way, 100 ft., regardless of the number of tracks. There are 32 joint subways, replacing as many grade crossings. In addition, the C., R. I. & P. Ry. has 14 subways, replacing 15 crossings, and the L. S. & M. S. Ry. has 3 subways, replacing 2 crossings. The yards at 43d St. (C., R. I. & P. Ry.) and at 18th St. and Englewood (L. S. & M. S. Ry.) have been raised. At Englewood a new union station has been built for the use of the above two roads and the P., Ft. W. & C. Ry., which latter crosses the C., R. I. & P. Ry. diagonally at grade. The work was briefly described in our issue of March 17, 1898.

The bridges and grading and paving in subways were done by contract. The bridges were built and erected by the Lassig Bridge & Iron Works, Chicago; American Bridge & Iron Works, Chicago, and the King Bridge Co., Cleveland, O. All other work was done by day labor under the direction of Mr. Clarke. The sand filling was hauled 30 miles, and was plowed off by a "rapid unloader," the plow being hauled along the train by an engine on the front car, taking steam from the locomotive.

The bridge over Archer Ave. has a solid floor of rectangular troughs, somewhat similar to the form introduced on the New York Central R. R. by Mr. Geo. H. Thomson. This bridge, with its floor construction, was illustrated in our issue of Oct. 11, 1894. On other bridges, the floor consists of 12-in. 32-lb. I-beams, 13 7-16 ins. c. to c. Those do not rest directly upon the chords of the girders, but the ends are cut at an angle of about 45°, and are riveted to angle iron brackets at the same angle. The tops of these brackets are riveted to the girder web, while the lower end is rivted to the top plate of the chord (which is wider than the others) or to a bent plate riveted to the under side of this wide plate. Gusset plates are riveted to the top flanges of the I-beams. Upon this floor is a decking of 5-16-in. plate. Each rail rests upon a ⅜-in. plate 16¼ ins. wide, which is riveted to the deck plate and beam flanges. On the outer side of this plate is an angle iron 6 × 4 ins., with its 4-in. leg vertical and its 6-in. leg turned inward. The rail is secured by bolted clamps, the bolt heads being under the deck plates. The bottom of the floor beam is level with the bottom of the girders. Fig. 10 shows the floor system, and Fig. 11 shows the rail fastenings employed, and also the guard rail.

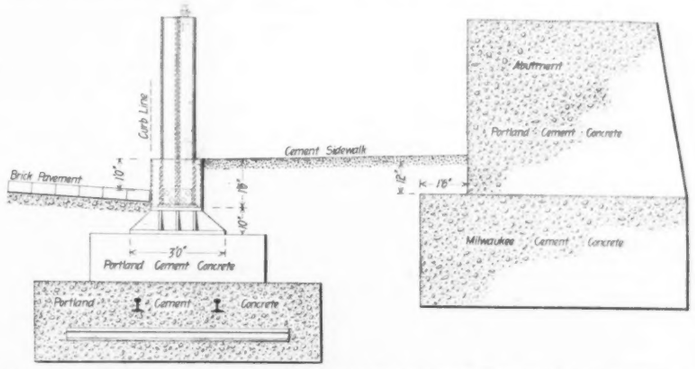



FIG. 8.—CONCRETE ABUTMENTS AND FOUNDATIONS FOR SUBWAYS; C., M. & ST. P. RY., CHICAGO.

At Englewood the grade crossing of the C., R. I. & P. Ry. and the P., Ft. W. & C. Ry., together with the yards, has necessitated a great area of bridging on 61st St., 63d St. and State St. These two railways have four tracks each, while the L. S. & M. S. Ry. has two main tracks and 26 yard tracks. For the yard tracks an entirely different style of bridge was adopted, through girders being avoided on account of their obstruc-

tion to crossovers, and the danger to switchmen and trainmen. Rows of columns on the curb line and in the middle of the 40 ft. roadway carry box girders parallel with the street. Each column has a 12-in. I-beam, with a 12-in. channel riveted to each flange, the flanges of the channels being inward, and connected by pattern plates. On the girders rest the ends of 15-in. I-beams, at right angles to which are 4-in. Z-bars. The whole is covered by deck plating, to which are riveted the rail bearing plates, which are as thick as the rivet heads and extend between the lines of rivets. Angle iron guard rails are also riveted to the

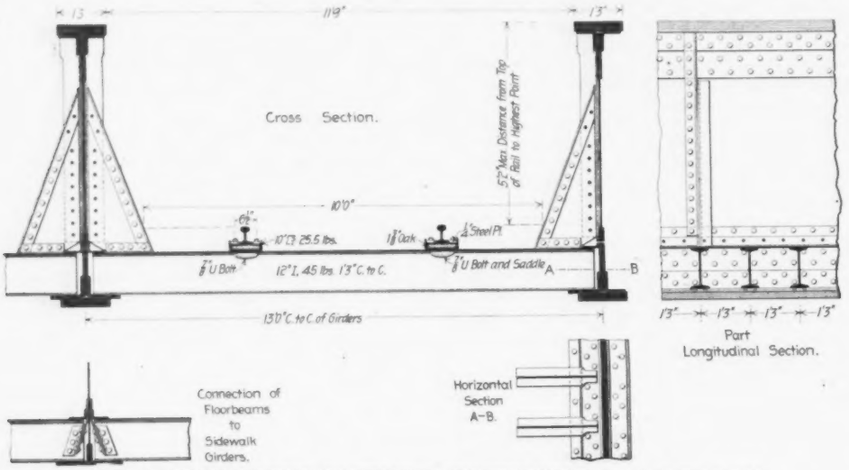

Cross Section.
Part Longitudinal Section.
Connection of Floorbeams to Sidewalk Girders.
Horizontal Section A-B.
130'0" C. to C. of Girders

FIG. 9.—BRIDGE FLOORS ON TRACK ELEVATION WORK; C., M. & ST. P. RY.

deck, while the rails are secured by bolted clamps. The bridging over 63d and State Sts. forms a continuous subway nearly 2,000 ft. long and crossed by 64 tracks.

It is probable that the work will eventually be extended north from 16th St. to Van Buren St. (although the 12th St. viaduct now forms an obstruction). This will necessitate the reconstruction of the terminal station at Van Buren St. and Pacific Ave., a project which has been several times under consideration. Negotiations are, in fact, already in progress in regard to this extension, and it is said that an agreement has been practically arrived at between the officers of the city and the C., R. I. & P. Ry. According to present negotiations, the 12th St. viaduct will remain, but the new elevation will commence at that point and extend north to the Van Buren St. Station. Taylor St. will be closed, but there will be bridges over Polk St. and Harrison St. This will leave an awkward sag at 12th St., but this appears to be necessary, as the existing viaduct crosses so many other railways, including yards as well as running tracks.

The St. Charles Air Line crosses at grade at 16th St.; the Chicago & Western Indiana R. R. and Atchison, Topeka & Santa Fe. Ry. pass under the tracks, also at 16th St. The Union Stock Yards & Transit Co.'s line passes under the tracks at 40th St. The work south of 16th St. is all that is covered by existing ordinances, and was finished last year.

### Illinois Central R. R.

The first piece of track elevation work done in Chicago was the elevation of the main line of this railway from 47th to 71st Sts., a distance of about three miles, of which the approaches represent one mile. The ordinance was passed in 1892, and stipulated that the roadbed should be wide enough for ten tracks. The railway had an average of eight tracks, with numerous sidings, and the total length of single track elevated was about 30 miles. The tracks were elevated about 10 ft., the streets being lowered to give a headway of 11 to 12½ ft., and in one case 13½ ft. Six grade crossings were eliminated, and 13 subways provided, including a footway tunnel 8 ft. wide. First-class rock-faced ashlar masonry is used for the abutments, and rubble and concrete masonry for the retaining walls. Work was commenced June 1, 1892, and completed May 1, 1893, the total cost being about $1,300,000. This work was originally designed by Mr. John F. Wallace, M. Am. Soc. C. E., in 1891, while Engineer of Construction of the I. C. R. R. On March 1, 1892, Mr. Wallace was appointed Chief Engineer, and the work of construction was carried out under his direction. The bridge work for the subways on this elevation, was under the direct charge of Mr. H. W. Parkhurst, M. Am. Soc. C. E., Engineer of Bridges & Buildings of the I. C. R. R., under the general supervision of Mr. Wallace.

The sand filling was first placed for one track on the east side of the work, with steep grades at the street crossings until temporary trestles were built. When this was completed the embankment was widened on the west side, and additional lines of trestles were built across the streets. The erection of the steel bridges was commenced on the east side and extended westward on each street. The total work included about 800,000 cu. yds. of sand embankment, 16,000 cu. yds. of masonry of all classes, and 6,300 tons of bridge material. The bridge floor system consists of transverse troughs whose section is that of a truncated pyramid. It is an English invention known as the Lindsay system, but the trough sections were rolled in this country. They are laid alternately open and inverted, the sides lapping and being riveted together at about the mid-depth of the completed trough. They are 16 ins. c. to c. and 6 ins. deep. The ends of the floor are riveted to shelf angles just above the bottom chords of the plate girders.

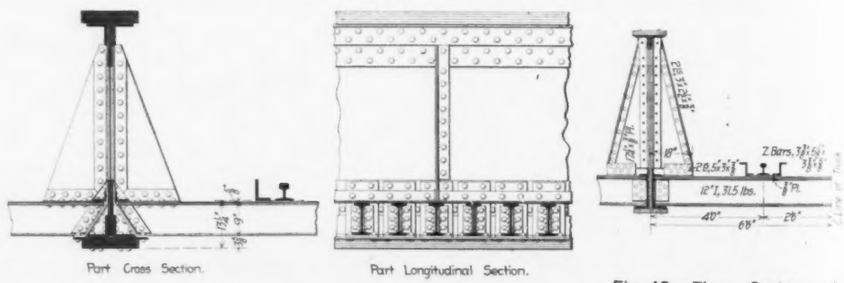



FIG. 10.—BRIDGE FLOORS ON TRACK ELEVATION WORK; C., R. I. & P. RY., AND L. S. & M. S. RY.

The rails are not attached directly to the floor, as in the floors already described, but are carried by timber ties. At first ties 5½ × 5½ ins. were used laid in the troughs. It was intended to raise them about 2 ins. by an asphalt concrete filling and to surround them with the same material, but traffic conditions did not allow of the tracks being given up sufficiently to allow of this being done. The later practice, therefore, is to use ties 5 × 8 ins., laid on top of the troughs, and secured by the guard timbers. In cases where the girders were 15 ft. c to c., the rails were bolted to oak stringers resting on the inner flanges of two 8½-in. deck beams bolted to the troughs, these beams forming the guard rails.

The bridges were built by the American Bridge Works, of Chicago. The masonry was also done under contract, but the filling and track work were done by the railway company.

From 47th St. northward, the tracks are partly below and partly on a level with the streets, but as the line is along the edge of the lake the streets do not cross the railway. The north end of the line, from the main terminal at 12th St. to the suburban terminal, at Randolph St., was level with the Lake Front Park. In 1895 an ordinance was agreed upon between the railway and the city by which the latter was to raise the level of the park about 8 ft., while the former was to lower its tracks about 4 ft. and to build bridges across, so as to give access to the new park on the east side of the tracks. This work was fully described by Mr. John F. Wallace, M. Am. Soc. C. E., in a paper on "The Lake Front Improvements of the Illinois Central R. R.;" Transactions American Society Civil Engineers, December, 1897. The work done by the railway company included the following: (1) a retaining wall more than a mile long on the west side of the right of way, (2) the filling for the new grade of the park between Michigan Ave., and the retaining wall, (3) the Van Buren St. station, (4) the lowering of the tracks between Park Row and Randolph St., (5) the construction of several viaducts over the tracks, and (6) the construction of 1½ miles of sea wall or bulkhead surrounding the 160 acres of submerged land east of the tracks, which is being filled in by the city and will be made a public park. The cost of all this work is estimated at $1,000,000.

Chicago, Madison & Northern Division.—This line turns west from the main line and runs a little north of 16th St. to the Chicago River and then turns southwest, parallel with the tracks of the Chicago & Alton Ry. and A., T. & S. F. Ry. From the main line to the river the line has been elevated, in connection with the St. Charles Air Line and the 16th St. crossing, described below. An ordinance has been passed for the elevation of the tracks of the three lines above mentioned, commencing at 18th St. and extending to the Illinois & Michigan Canal, about 4 miles. This has already been referred to in connection with the work of the Atchison, Topeka & Santa Fe Ry. The joint track elevation of the A., T. & S. F. Ry. and the C., M. & N. Ry., from 18th St. to Ashland Ave., will be done under the direction of Mr. G. W. Vaughn, M. Am. Soc. C. E., as Engineer in Charge. Mr. Vaughn was engineer in charge of the joint track elevation and depression work at the complicated 16th St. crossing noted below.

St. Charles Air Line.—This line, already referred to, extends west from the main line of the Illinois Central R. R. to the west side of the Chicago River, and is owned partly by the I. C. R. R., the C., B. & Q. R. R., the C. & N. W. Ry. and the M. C. R. R. The length is 1.25 miles, and there are four tracks for half the distance and two tracks for the remainder. there being 2.5 miles of single main track elevated. The elevation averaged 15.5 ft., this being greater than usual on account of the fact that no change in grade could be made on the I. C. R. R. main tracks or on State St. There are 13 subways, including 6 streets, 3 alleys, and




Fig. 12.—Floor System of Bridges on Track Elevation; St. Charles Air Line.

the L. C. R. R., A., T. & S. F. Ry. and C. & W. I. R. R. The tracks of the L. S. & M. S. Ry. and the R. I. & P. Ry. are crossed at grade on the elevated line. Work was commenced in May, 1898, and completed by May, 1899, at a cost of about $[illegible],000, including the C. M. & N. Ry.

The east approach incline is on the east side of the L. C. R. R. main tracks, which are crossed on the skew, and at the west end the drawbridge over the river had to be raised 6½ ft. The street abutments are of first-class bridge masonry, the alley abutments and the retaining walls being of second-class coursed ashlar masonry, with rubble backing. A peculiarity of the masonry retaining walls is that they are built in sections of about 100 ft., with vertical joints (Eng. News, March 9, 1899). The reasons for this are as follows: (1) To form expansion joints and prevent the tearing open of mortar joints or the breaking of stones; (2) to vary the thickness of the courses, and so facilitate the rapid construction of the masonry, as it is difficult to get long continuous courses of a given height; (3) an incidental advantage is that it permits more freedom in settling, the foundations being somewhat uncertain.

The masonry was built first along the north side of the right of way, with the north end of the abutments, and a temporary single track trestle was then built on this side. Traffic was then diverted to this track, and the south wall and south part of abutments completed. The filling is of slag, dumped from gondola and side-dump cars on the trestle. The 300-ft. double track drawbridge was raised by means of jacks placed under the panel points, the center and the turntable rim, the rim and track being tied together by suspension bolts. It was first raised 5 ft. and supported temporarily by timbers for some weeks, the west approach being temporarily graded up. During this time the timber abutments were replaced by concrete built in sections. It was then raised 15 ins., adjusted to a grade of 1%, and the concrete pier built up.

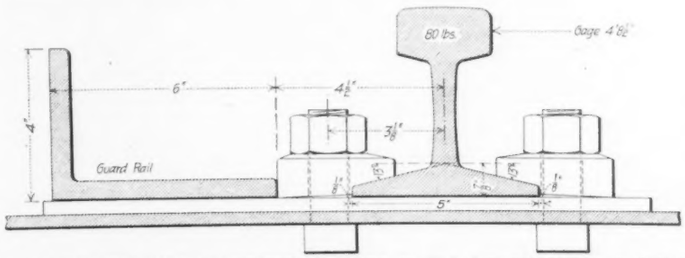



FIG. 11.—RAIL FASTENINGS ON BRIDGE FLOORS; C., R. I. & P. RY. AND L. S. & M. S. RY.

The floor system of the fixed bridges generally consists of 12-in. 31½-lb. I-beams, 12 ins. c to c., just above the bottom chords of the girders, with their webs riveted to angle brackets or knees on the webs of the girders. Over these beams is a deck of ⅜-in. plate, cambered transversely about ⅝-in. by filler plates on the beams. The rails rest on beveled plates which take out this camber, and Z-bar guard rails are placed on each side, riveted through the rail plate, deck and beam flanges. This construction is shown in Fig. 12.

All work was done by contract, with the exception of the filling and track work. The bridges were built by the Detroit Bridge & Iron Works. The work was planned and executed under the direction of Mr. John F. Wallace, Assistant Second Vice-President of the Illinois Central R. R., by Mr. H. W. Parkhurst, Engineer of Bridges and Buildings, Illinois Central R. R.

Pittsburg, Cincinnati, Chicago & St. Louis Ry.

The work on the Rockwell St. line, done in connection with the Chicago & Northwestern Ry., has already been described. The cost of the track elevation on Rockwell St. was about $292,000. Under the provisions of the ordinance passed by the city on May 22 this road is required to elevate its tracks from Western Ave. to the Illinois & Michigan Canal, a distance of 1.27 miles. The estimated cost of this work is $301,000. Mr. Thomas H. Johnson, M. Am. Soc. C. E., is the Chief Engineer.

According to an agreement arrived at between the railway company and the city on Feb. 13, the tracks running east and west in Kinzie St. (parallel with the Chicago & Northwestern Ry.), will also be elevated. This will form a continuation of the track elevation on Rockwell St. (running north and south). The city will vacate Rockwell St., south of Monroe St., which will add 33 ft. to the east side of the right of way. This street is already largely occupied by tracks and sidings. In return, the railway company will buy and present to the city a strip of land for a street on the west side of the right of way, extending from Monroe St. to Van Buren St. The work on Kinzie St. will help to advance the work on the Chicago & Northwestern Ry. and the Chicago, Milwaukee & St. Paul Ry. There still remains a settlement of the difficulty as to the work at Western Ave. and 16th St., where the tracks of the P., C., C. & St. L. Ry., the C., B. & Q. R. R., and the Chicago Terminal Transfer R. R. intersect. The former road wishes to retain the present street viaduct, of the cost of which it paid $90,000. The C., B. & Q. R. R. is willing to elevate its tracks west of the viaduct and east as far as its freight yards, but no further. The legal advisers of the city hold that as the railways have already been compelled to abolish grade crossings by carrying the streets over the tracks on viaducts, they cannot now be compelled to adopt another plan, by elevating the tracks and removing the viaducts. The railway companies will, therefore, be left to determine among themselves whether to adopt this latter plan or to repair the viaducts.

Pittsburg, Fort Wayne & Chicago Ry.

Under an ordinance passed in 1896, the track has been elevated from 52d St. to South Park Ave., and the work is being continued to Grand Crossing. The Englewood Connecting Ry. has also been elevated from Butler St. to Stewart Ave. The work of this company is to be completed by elevating the tracks northward from 52d St. to the Chicago River at 18th St.

The distance from 52d St. to South Park Ave. is 2½ miles, with four tracks, making 10 miles of single main track. The average height of elevation is 12 ft., and 15 subways have replaced as many grade crossings. The abutments are dimension masonry of Lemont limestone and the retaining walls are of the same rubble masonry, with Bedford oolitic stone coping. All the work was designed by and executed under the direction of Mr. Thomas Rodd, M. Am. Soc. C. E., Chief Engineer. The work was done by contract, the steel bridges being built by the American Bridge Works, of Chicago.

The right of way is 66 ft. wide, and the two western tracks were first raised, the eastern (or running tracks) being also raised between the streets on account of the filling encroaching upon them. The girders were laid upon temporary trestle bents during the execution of the work. Cribbing of old ties was used for the temporary approaches, and at the eastern end of the work the cribbing extended from street to street, the height being about 8 ft. The girders, weighing 25 to 40 tons, were handled by a derrick car, one end at a time, and the floor was then put in by this car, while standing on the running tracks. As soon as the bridge was ready, the cribbing was built at each end, sand filling put in, and the street excavated sufficiently to allow fire engines to pass, this being at the special request of the Fire Department.

The floor system consists of triangular troughs, resting on the bottom chords of the girders and on angle, or inverted V, lugs riveted to the webs. This is covered with ordinary stone ballast, the base of rail being 6½ ins. above the apex of the trough. With this arrangement the noise heard in the subway when a heavy train is passing is very slight.

The cost of elevating the tracks from 51st St. to St. Lawrence Ave. was about $1,000,000, and to complete the work to Grand Crossing will cost about $500,000, or $1,500,000 in all. The extension of the work northward from 52d St. to the Chicago River, as provided by the city ordinance of October, 1899, would cost about $2,500,000. The ordinance for this extension, which would have to be carried out in conjunction with the elevation of the parallel lines of the Chicago & Western Indiana R. R. (Eng. News, Jan. 11), has not yet been accepted by the company. In January last the city proposed to bring the company to terms by passing an ordinance compelling all trains on the P., Ft. W. & C. Ry. to come to a full stop within 100 ft. of the crossing of 22d, 26th, 71st, 39th, Root and 47th Sts., and Archer Ave. This was laid aside, however, pending further conference.

On Feb. 13, an agreement was arrived at between the city authorities and the railway officers, by which the latter agree to elevate the tracks south from 18th St., and to provide subways at all streets crossed. An ordinance is now being prepared on the basis of this agreement, and it is thought there will be no further opposition to the work.

Sixteenth St. Crossing.

This complicated crossing was the most dangerous and the most difficult to deal with of all the crossings in Chicago. The methods adopted for its elimination have been fully described in our issues of July 14, 1898, and April 13, 1899. The principal features are as follows: (1) The parallel north and south tracks of the L. S. & M. S. Ry. and C., R. I. & P. Ry. have been elevated; (2) the east and west lines of the A., T. & S. F. Ry. and C. & W. I. R. R. have been depressed to pass under those above mentioned; (3) the east and west tracks of the St. Charles Air Line and the C., M. & N. Ry. have been elevated to pass over Clark St., but still cross the tracks of the L. S. & M. S. Ry. and the C., R. I. & P. Ry. at grade; (4) the grade of Clark St. has been altered so that it passes under tracks (3) and over tracks (2), the street being parallel with tracks (1). Mr. James Dun, M. Am. Soc. C. E. (Chief Engineer of the A., T. & S. F. Ry.) was Supervising Engineer, and Mr. G. W. Vaughn, M. Am. Soc. C. E., Engineer in charge.

The following official statement of the several tracks altered on this complicated crossing will give some idea of the nature and difficulty of the work:

Tracks Elevated.

| | No. of tracks. | Length of track, ft. |
|---|---|---|
| C., R. I. & P. Ry., main line, 15th to 17th Sts. | 2 | 2,060 |
| L. S. & M. S. Ry., main line, 15th to 17th Sts. | 2 | 2,060 |
| C., R. I. & P. Ry., and L. S. & M. S. Ry., 15th to 16th Sts. | 1 | 900 |
| C., R. I. & P. Ry., and L. S. & M. S. Ry., 17th St. to river | 2 | 1,800 |
| C., R. I. & P. Ry. and L. S. & M. S. Ry., 15th St. to river | 2 | 1,370 |
| Ill. Cen. R. R., main line, 18th St. to Clark St. | 2 | 2,960 |
| St. Charles Air Line, main line, Clark St. to river | 2 | 1,500 |
| C. & W. I. R. R., switch track, 18th to 16th St. | 1 | 930 |
| C. & A. R. R., switch track, 18th to 16th St. | 2 | 1,320 |
| A., T. & S. F. Ry., coal track, Clark to Dearborn St. | 1 | 330 |
| Total | 2.88 miles, or | 15,230 ft. |

Tracks Depressed.

| | | |
|---|---|---|
| C. & W. I. R. R., main line, 14th to 17th St. | 4 | 2,800 |
| C. & W. I. R. R., coach yard tracks, 16th to 17th St. | 5 | 750 |
| C. & E. I. R. R., yard tracks, Clark to 15th St. | 5 | 1,650 |
| C. & G. T. Ry., yard tracks, Clark to 15th St. | 2 | 325 |
| Erie R. R., yard tracks, Clark to 15th St. | 11 | 2,350 |
| A., T. & S. F. Ry., main line, Dearborn to 18th St. | 2 | 4,200 |
| A., T. & S. F. Ry., yard tracks, 16th to 18th St. | 11 | 2,890 |
| Total | 2.83 miles, or | 14,965 ft. |

The total length of tracks elevated and depressed was equivalent to 5.71 miles of single

track. The average height of elevation was 12 ft.; average depth of depression, 9.5 ft. All the retaining walls and abutments are of Portland cement concrete, and the steel bents (between the depressed tracks) for the bridges are enclosed in concrete protection walls 21 ins. thick, to a height of 10 ft. above the ties. The bridges have through plate girders, with floors of 15-in. I-beams laid close together transversely between the girders. For the Clark St. bridge the floor is of 8-in. I-beams, spaced 2 ins. apart, having concrete filled in between them and to a depth of 2 ins. above their top flanges. On the concrete is a layer of sand, upon which are set the granite paving blocks. Day labor was employed for all the temporary structures, the raising, lowering and shifting of tracks as the work progressed, and the laying of the new works. The concrete masonry was built by the Brownell Improvement Co., of Chicago. The steel bridges were built by the American Bridge Co., of Chicago; the Lassig Bridge & Iron Works, of Chicago, and the Detroit Bridge Works, of Detroit, Mich. Work was commenced April 24, 1898, and completed April 1, 1899. The cost was about $500,000.

## THE DESIGNING OF SKEW CONNECTION DETAILS FOR ROOF AND BRIDGE WORK.*

By C. A. P. Turner, C. E.†

(With two-page plate.)

II.

### Skew Details in Bridge Work.

In taking up the skew details in bridge work, it is well at the outset to call attention to their similarity to those met in roof work, that the bridge draftsman may have little trouble with the former or the roof draftsman with the latter. As we shall see, the bevel angles involved in the skew portal, are identical with those for normal purlin connections, and in the discussion to follow, similar angles will be designated by the same letters as in the preceding discussion, Eng. News Feb. 15, 1900.

Types of Skew Bridges.—Where stirrups or bar hangers are used, as is generally the case in the cheaper class of highway bridge work, if the skew is small it is customary to skew the floor beams and top struts, making the trusses symmetrical. This requires a somewhat heavier section for the floor beam, since it has to carry the same load, with span increased by the co-secant of the angle of skew with the center line of the bridge.

While this increase in section and length of beam amount to little in a light highway span, it would amount to considerable in a heavy railway bridge, and further, where the stringers are riveted between the beams, the bent plate work would be expensive, so that for heavy work the end panels are usually made of different lengths by inclining the hip vertical. The span is now symmetrical about the center line (although the trusses are unsymmetrical), the end posts have the same inclination, while the floor beam and stringer connections are all square.

Another way of designing a skew Pratt truss span is to give the end posts different inclinations, making a difference in the end panels equal to the skew; with this the connections of beams are square and the hip suspenders are vertical. The form of portal should preferably be a vertical strut, placed above the chords and connected to the end posts by brackets.

Where the depth of the truss is so great that a lattice portal connecting to the batter posts is desirable, this arrangement should be avoided, as it involves a twisted skew portal. Where it is possible to vary the skew slightly, making it in even panel lengths, it is desirable to do so. Where the skew is approximately, two or three panels, we may make the panels at the end slightly longer or shorter than those of the remainder of the span and thereby avoid inclining the hip verticals.

The bevel angles involved in the skew portal or frame are as follows: I = the angle of inclination of the end post with the horizontal. B = the angle between the plane of the truss and the center line of the portal strut, measured in a horizontal plane.

All requisite bevel angles are functions of I and B, and are as follows: P = the amount the angle between (1), the center line of portal strut and (2), the line of intersection of plane of the portal, with the plane of the truss differs from 90°. A = the angle between the plane of the portal and a horizontal plane. G = the amount the angle between the plane of the portal, and the plane of the truss differs from 90°. M = the amount the angle between (1), the plane of the truss, and (2), a plane perpendicular to the plane of the portal and through the center line of the portal, differs from 90°. X = the angle between (1), a vertical line in the plane of the truss and (2), the line of intersection of the plane of the back of the portal with the plane of the truss. Z = (X-I) = the angle measured in the plane of the truss, between a plane normal to the center line of end post, and the line of intersection of the plane of back of portal, with the plane of truss. V = the amount the angle differs from 90°, between the center line of portal strut, and the line of intersection of the plane of the truss with a plane perpendicular to the plane of the portal through the center line of portal strut. The more useful relations between these angles were derived in discussing the normal purlins.

Fig. 21 shows a type of portal frequently used for highway bridges, consisting of a vertical top strut with portal brackets. A, P and G are the requisite angles for this portal. Cot A = Cot I . sin B; Tan G = Sin I . cot B; Tan P = cot I . sin G; Tan P = Cot B . cos A. Figuring P by the two equations checking the set. (B and I being known.)

Fig. 22 shows a skew brace frame, involving the angles G, P, V, M and Z. (1) Cot A = cot I . sin B; (2) Tan G = sin I . cot B; (3) Tan P = cot B . cos A; (4) Tan V = sin A . cot B; (5) Tan M = cot A . sin V; (6) Tan Z = tan P . sin G = sin M . tan V.

While it would be shorter to use the equation, tan P = cot I . sin G in place of (3), and tan M = tan P . cos V in place of (5), and tan V = tan G . sec P in place of (4), the writer prefers to figure the set as above, since while longer, by figuring Z for the two values, we have a check on the other results, which would not be the case were the angles not figured through A, which is otherwise not needed.

Fig. 23 shows a common form of box portal, connecting to the flanges of the end post.

For this portal, we need the two angles P and G only, and we wish the dimensions or distances t, s, m, n, and l. The formulas are: Tan G = sin I . cot B; sin P = cos B . cos I; tan P = cot I . sin G; $l = (c - 2h) \div \sin B$; e is known; t = e sin G; s = t sec P; n = t tan P; m = e cos G.

We may check the above quickly by squares, since $d^2 = (e^2 + n^2) = (s^2 + m^2)$.

The angles V, Z and X are shown, though we have no need to use them.

We might derive a number of relations between the bevel angles readily, from the obvious relations between these distances. Thus: t = e sin G; m = e cos G = d cos V; s = m tan V = d sin V = t sec P; n = t tan P = e tan Z = s sin P = d sin Z; d = e sec Z; from which we may readily obtain Tan Z = tan P, sin G and sin Z = sin P, sin V, etc.

In checking a skew brace or portal, note particularly whether the skew is right or left, and see that P is laid off accordingly.

Next, check the center line lengths between reference planes, and if this agrees with that given on the drawing, proceed; otherwise find what distances or offsets h, the man making the drawing used in figuring, since a slight discrepancy in these distances to the bend lines, arising from an error in tracing or copying notes, would change slightly nearly every figure on the drawing, and which would be right with a slight correction in these distances.

This point, in fairness to the man with whom he is working, should be kept in mind by a draftsman checking; the writer having had instances come to his observation, where the checker, not having had this in mind, consequently reported to his chief that he found the work of a capable man about all wrong, whereas, the only trouble lay in the error of a careless tracer in copying the gage from the bend line to the line of open holes.

Where the skew of the bridge is great, say two or three panels, a box portal strut becomes too narrow, if connected to the inner flanges of the end posts, in a manner similar to the box portal shown by Fig. 23. There are two ways of obviating this; the first and better way is to connect to the diagonally opposite flanges of the end posts, and, second, we might make a swell belly strut of the portal.

Fig. 24 shows the general details of the portal for the Sheppards Creek Bridge, Lehigh Valley Ry., which is of the former class, connecting to the diagonally opposite flanges of the end posts; an auxiliary top strut was used, supported by the portal, for the connection of the short top lateral strut.

By referring to the small sketch at the upper left-hand corner of the drawing, it will be seen that the upper inner flange angle, passes between the main tie bars, so that the position which will allow this angle to clear the ties, fixes the maximum height of the portal. It is quite a little work to determine this clearance, which may be avoided by making the portal of the section suggested at the right of the diagram, thereby increasing the strength of the portal, and saving something in weight, and making a simple connection to the top chord and short struts. The lattice angle webbing of the portal, should preferably be arranged as shown in Figs. 23 and 24, since when looking at the portal from any position on the center line of the bridge produced, the web angles all appear to have the same inclination to the horizontal, giving a more pleasing appearance.

For this portal, we have the auxiliary bevel angle which we will term R, which may be defined as the angle between the reference plane and the plane of the truss. This reference plane will be passed through the bend lines at one end of the portal, but in general it will not be convenient to pass it through the bend lines at both ends of portal, since these reference planes should be parallel. This angle R is fixed, when we have decided the position of the bend lines through which we pass the reference plane. See section of end post at right-hand side of Fig. 24.

Figure angles A, P and G as for preceding portals and take the difference between G and R. Then: $l = (c - 2h) \operatorname{cosec} B$; r = e sec R; t = r sin (G — R); m = r cos (G — R); n = t tan P; $s = t \div \cos P = \sqrt{n^2 + t^2}$.

Frequently, in place of knee braces from the top struts to the vertical posts, the struts are made several feet deep and latticed where the head room permits.

In case the skew is two or more panels, if this construction is carried through, we should have the vertical web of a horizontal short strut, intersecting the web of the portal.

The requisite bevel angles would be: (a) The angle between the plane of web of portal and the vertical plane of the strut. (b) The angle between a horizontal line in the vertical plane of the strut, and the line cut from the strut by the plane of web of portal. (c) The amount the angle differs from 90°, between the center line of portal, and the line cut from the plane of web of portal by the plane of web of strut.

For convenience, consider the web of portal as a roof plane inclined at the angle A to the horizontal, and the vertical plane of strut as a plane of the web of a hip; then B, under this treatment would be the complement of the skew B of the portal.

Figure I′, P′ and G′, by the preceding formulas, using (90 — B) as B′, then, (a) = comp. G′; (b) = I′; (c) = P′.

In case the strut is shallow and connects to the back (top) of the portal strut, we should have three more bevel angles, viz., (d), the angle of inclination with the vertical, measured in the plane of the strut; of the line cut from the plane of the strut by the plane of back of portal. (e), the angle between the vertical plane of the web of strut and the plane of back of portal. (f), the amount the angle differs from 90°, between the center line of plane of back of portal, and the line cut from it by the vertical plane of the strut.

Figure X′, M′ and V′, by the preceding formulæ,

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†Engineer, the Gillette-Herzog Co., Minneapolis.

using as before, complement of the skew angle with the center line of bridge for B, and the inclination of web of portal with horizontal for A, and we have: (d) = X'; (e) = comp. M'; (f) = V'.

In the derivation of the relations between the bevel angles in roof work, we have called attention to the fact, that a portion of the various relations which may be derived by the principles of spherical trigonometry, are of more value than the others, and should preferably be used. Since projecting the spherical triangles applicable to any case in more complicated than to treat the case in the manner that we have the last two skew connections, it will generally prove simpler to use the selected formulas for all cases, adapting them by analogy to the case in hand. We have noted in a general way, similarity between the bevel angles of the normal purlin and those of the skew portal, and it remains to add that the connections of the portal to the end post farthest from the center of the span, are identical with those of the normal purlin to a hip rafter; while the portal connections to the end posts nearest the center of the span, are essentially similar to the normal purlin connections to a valley rafter in roof work.

### Hoppers.

Given the angle of slope of one side with the horizontal = A, and the angle of slope of other side with the horizontal = B; and the angle of intersection = c minor, of the lines cut from a horizontal plane by the planes of sides of hopper.

Let C major equal the angle between the planes of the sides, then from the spherical triangle, A B C, Fig. 25, we have equation (H), cos C = — cos A . cos B + sin A . sin B . cos c.

Or, we may treat the sides of the hopper as two roof planes, and using the notation given for roof

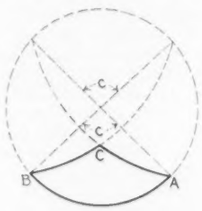


Fig. 25.

bevels, we have C = 180° — (Ga + Gb). If A = B = 45°, and c = 90°, cos (180 — 2 G) = — cos A² = — 5, the cosine of 120°, which is 180° — 2 × 30°; G being 30° for 45° slopes, c minor equaling 90°. Equation (H), is the simpler solution only when the slopes are unequal, and c minor greater or less than 90°. When c minor is 90°, 120° or 135°, and the slope angles are equal, we may determine the bevels at once by taking tan G from the bevel diagrams, Figs. 12, 13 or 14, and laying it off twice as per Fig. 26.

The bevels for the connection of struts to columns, in pyramidal towers, where the sides have equal inclination, can be taken in like manner at once from the bevel diagrams for square, hexagonal or octagonal roofs.

### Spherical and Conical Roofs, etc.

In hemispherical roofs or domes, if the purlins are tees or angles, and are bent around horizontally, they must be twisted as well as bent to the curve of a small circle. Where, for instance, the dome is sheathed, or the copper or slate roofing is supported by a cinder concrete and expanded metal ground, we may bend all the purlins to the curve of a great circle, and avoid this troublesome twisting; splicing them, of course, at each rib. When this is done, the purlins are no longer exactly parallel, but near enough so for practical

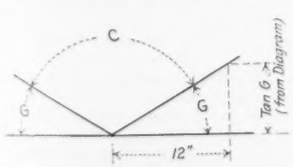


Fig. 26.

purposes. Suppose it is desired, where the purlins are angles, to connect them by a lug angle where they splice on the rafter or rib, in addition to bolting to the back of rib. This clip angle should be bent to an angle of 180° — 2G. Let N equal the number of ribs or rafters spaced equally. Let $B = \frac{90° (N - 2)}{N}$. Let I = the angle of inclination with the horizontal of a radial line, which touches the face of the clip angle and lies in the plane of the great circle, which cuts the center line of the rib from the sphere, Fig. 27. Then tan G = sin I . cot B, an equation

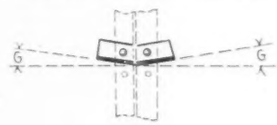


Fig. 27.

which is identical with what we have previously derived.

The treatment for a conical roof is similar; the purlin in this case being bent in a plane, normal to an element half-way between the consecutive ribs. Let A equal the angle of slope of an element of the cone with the horizontal; then the curve cut from the cone by the above plane is a parabola when A equals 45°; an ellipse, when A is greater than 45°; and an hyperbola, when A is less than 45°. It will generally be sufficiently accurate to treat the curve as parabolic, thus making the determination of the ordinates very simple.

The bent angle connection was selected for illustration, not as a cheap and practical detail; but rather that by means of it, the bevel of the line of the intersection of the plane in which the purlin is bent, with the back of the rib, could be better illustrated, than by describing it otherwise.

In a dome in which the purlins lie in planes of great circles, the bevel angle G, varies with each purlin between the limiting values of zero at the base, to complement B at the top, and the simplest solution of all values required for tan G, would evidently be to plot the curve of values of tan G, for I variable between zero and ninety degrees. To do this, we have only to figure three intermediate values, say: for I = 30°, tan G = ½ cot B; for I = 45°, tan G = .707 cot B, and for I = 70°, tang G = .94 cot B, which, with the limiting values known, we may draw the curve with sufficient accuracy for practical purposes.

If the dome is a large one, it may be desirable to use latticed purlins, the top flange being curved and the botom flange straight, and making the connection to the web of the rib. In this case the angle between the web of the purlin and the web of the rib is 90° — G.

Since both the web of the purlin and the web of the rib lie in planes of great circles, their line of intersection is a radial one, and therefore normal to the curves of the center lines of the back of the rib and purlin at their point of intersection.

In general, when the problem involves a number of variable bevel angles, it is simpler to plot a curve giving all values of the tangents, and this may be done by figuring but a few values for each curve.

For the tangent of Z when B is 60° or greater we need to figure only its value for A = 45°, and construct the curve as a parabola, the result being accurate enough for practical purposes. When B is less than 60° the curve is still approximately a conic section; but the difficulty of constructing the hyperbola which is almost identical with it would be much greater than to figure the necessary points for location. Since P and M are, respectively, equal to V and G for complement A, it is necessary to plot but two of these curves for the four angles.

We may also get these values in another way. If we consider V to vary with respect to A, and G to vary with respect to I, then for any value of I = A we have tang G = tan V. Thus with a curve giving the values of I for A variable, we could read the tangents of all four angles P, M, V and G for any slope from the curve of tangents of one of the four. Conversely if we have the curves of the tangents of the angles V and G plotted for consequence values of A in degrees as abscissas, we may read off the value of I in degrees for any value of A as follows: Note the ordinate on the curve of tang G for the given value of A and read off the abscissa for an equal ordinate on the curve of tan V and this will be the value of angle I in degrees for this value of A. Thus in diagram Fig. 12 for A = 50°, tang G is approximately 8½ ins., and under 8½ ins. on the curve of tan V we read 45°, which is approximately the value of I when A = 55° and B 45°.

In small domes it is generally best to make the connection of all ribs at the top alike; but in larger ones, for convenience in erection, it is better to frame four of the ribs together which are at right angles to each other, and to connect the others to them and to each other by plates, as shown in sketch of detail used by the writer in the design of the steel work for the Capitol Building at Helena, Mont., Fig. 28.

Where an A roof is finished with a conical end, the connection of the radial trusses of the half cone to the main truss presents some difficulty, particularly in heavy work, in properly providing for the secondary stresses due to eccentric loading of the main truss at the peak. The writer's provision for these stresses in designing the steel frame of the roof for the Music Hall portion of the Carnegie Library at Schenley Park, Pittsburg, which is illustrated in the detail sketch, of Fig. 29, may prove of interest from its novelty and perhaps offer a suggestion in some cases where the roof is equally large and the construction heavy. The detail illustrated allows all radial trusses to be made alike, while the diaphragm plates at the peak of each top chord when in position, butted together with the jaws of the hanger and peak strut riveted to them, make a very rigid detail. It is needless, perhaps, to remark, that the outline of the main truss was determined by the amount of space allowed by the architect, the arrangement of the webbing only, with the outline fixed, being governed by economic considerations. The bottom chord was made of channels for convenience in attaching the ceiling frame.

In concluding our discussion of skew connections, a word concerning the strength of the bent plates with which they are made may not be amiss. Two classes of stress or loads are to be considered: (a) direct along the length of the plate, and (b) transverse or bending stress. Under (a) we must consider both tension and compression. To resist tensile stresses the rivets should be so grouped that the line of pull is central to the connection, and so that the whole group will be brought into play at once instead of one or part at a time by the bending of the plate.

Sketch (a), Fig. 30, being a very good illustration of how not to do it; while (b) in the above respects, conforms to good practice. The rivets in such a case should be as near the bend as possible and unless the plate is of ample section the bending stress should be figured.

Under compression, unless the section is very excessive, it should be figured as a column when the thickness is less than one-twentieth of the unsupported length; and if the plate is not supported directly under the bend, the resulting bending stress should be considered in connection with the compression.

Where a bent plate supports a transverse load by bending, as in Fig. 31, if the outer or cantilever end is securely riveted to the piece, the plate may be correctly figured as a cantilever under the transverse force as follows:

Let S equal that part of the transverse force or shear transferred to the support of the bent plate, and d equal the distance from the bend to the end of the piece; then the bending moment on the plate is $\frac{1}{2}$ S d. By taking d to the back of the bend, we have allowed for the center of pressure on the plate under the toe of the piece being somewhat back of the extreme end.

The distance from the end of the piece to the bend should, of course, be made the least that proper clearance permits, and in the majority of cases it can be made so small that figuring on the bending strength of the plate is unnecessary.

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Prof. Taylor's article in this issue on the silting-up of the reservoir formed by the dam across the Colorado River, at Austin, Tex., may well serve to call attention to the desirability of providing some means of scouring out such deposits when dams are built on silt-bearing streams. As this is a masonry structure, waste and scouring conduits, it would seem, might have been provided with no great trouble.

As if to lighten somewhat the more serious phases of the silting-up process and the leaks in the dam, at Austin, the opponents of municipal ownership have seized with avidity upon these troubles in that city as another strong argument against municipal ownership. If there are any reasons why the very same engineers who built the Austin dam might not have been employed in the same capacity if it had been built by private capital, instead of the city, we should like to hear them. Or is nature itself against municipal ownership?

The quantity of material burned during the year 1898 in the garbage furnace at Montreal was unfortunately not given in the article on the operation of the furnace published in our issue of Dec. 7, 1899. We have since learned from Mr. J. E. Dore, City Sanitary Engineer, that the total quantity of matter burned in 1898 was 19,824 short tons; also that the total operating expenses of $14,000 for the year included no charge for water consumed or for insurance. The only insurance carried is $5,000 on the roof and approaches to the furnace. Besides the 19,824 tons of stuff burned there were 2,616 tons of ashes screened out during three months of the winter, which was from one-half to three-fourths of the volume collected for the same period. The total expense of $14,000 included lighting, repairs, labor incident to burning and carting away cinders and also the cost of screening out and carting away ashes. In other words, 22,440 short tons of ashes and garbage were finally disposed of for $14,000, not including water, insurance, and capital charges, or an average of 62 cts. per ton. The mechanical separation of ashes and garbage during the winter months raises the question whether it would not be advisable to require householders to keep them separate, not only in the winter, but all the year around. Unmixed with garbage, as we have several times pointed out, ashes may be used for filling, often with great saving in haulage. The labor account at the furnace is greatly increased by the ashes, whether the latter are run through the furnace or screened out. As a partial balance to this is the greater economy of one over two collections, that is, running one set of carts for garbage and another for ashes; and it is claimed that the combustible matter in the coal is one of the reasons why no fuel is used at Montreal except that in the refuse itself. However the question may be regarded, it must be remembered that the figures of cost given include the final disposal of ashes, as well as garbage, together with the cost of screening out and carting away the ashes during the winter months. One point of interest is the average daily amount of material collected. On a basis of 365 days in the year this averages, for the 22,440 short tons of mixed refuse, about 60 tons a day; or 71 tons for each working day (313 in all). The amount of refuse burned, 19,824 short tons, was about 63 tons per working day.

In commenting upon a recent editorial in the "Springfield Republican," bewailing the scarcity of water in that city as a result of a six months' drought, Mr. Clemens Herschel, M. Am. Soc. C. E., gives some timely advice to the residents of Springfield which would apply equally well to many other communities. He calls attention to the fact that of the water gathered, pumped and distributed at great cost by the majority of American cities, the so-called consumption is represented by 40 per cent. use and 60 per cent. waste, as a conservative statement by those who have investigated the problem; and the relative waste and use sometimes take the proportions of 3 to 1. An unknown part of this waste of water is chargeable to leaking distribution pipes, due to bad work in pipe-jointing in the original laying, or to disturbances of the soil by later work and the consequent settlement of the pipes. This wasted water finds its way by unseen channels in the soil to the nearest sewer, and unnecessarily adds to the duty of the sewer and to the volume of sewage to be finally disposed of. The rest of the waste occurs in the house fittings, and results from bad workmanship, lack of attention to repairs, and the wilful waste by occupants, who, paying an arbitrarily fixed water-rate, feel at liberty to squander as they please the costly supply of water reaching their houses. The outcome of all this waste is usually a "scarcity" in water supplied, and a loud outcry for an extension of the water-works. New York is a case in point. After spending many millions in impounding water and in leading it to the distribution service of the city; and after actually securing a supply that under intelligent and proper use would be sufficient for a city of five million inhabitants, we find that it is insufficient for the demands of a population of a little over two millions.

The remedy is a simple one, as Mr. Herschel points out in his letter to the people of Springfield. Reliable and moderate-priced house-meters can now be purchased in abundance in the open market; and we also have a meter that is adapted to pipes of any diameter, by means of which the leakage in street mains could at least be measured, and in large part located and checked. Instead of spending millions for an extension of the supply system, and furnishing more water to be wasted in the manner pointed out above, it would be much wiser to devise means of more economically utilizing the supply on hand—by stopping the waste. To accomplish this end requires intelligent, persistent and systematic work on the part of those in charge of our water supply, in first ascertaining the amount of waste due to leaking street mains and house-fittings. As the correspondent referred to says, this is a thankless and unappreciated task, and will be undertaken only from a sense of duty and real devotion to the public interests. That it will pay the city, so fortunate as to have men in charge of water supply, intelligent and devoted enough to undertake the disagreeable work of checking waste, is made evident by the results in European water-works practice, where 90 per cent. of the water supplied is honestly accounted for. The same figure has been attained in this country in some exceptional cases. With the waste in leaky street-mains checked, the general adoption of the house-meter will do the rest. As has been said before in these columns, the idea that the use of meters are unsanitary and that water should be free as air," is pure nonsense. The water meter is an instrument for enabling the actual total cost of the water supplied to be equitably distributed among all consumers. It in no way restricts the legitimate use of water, but it does check waste. The fact that all the water escaping from the house-taps is being silently measured, and will appear on a bill to be rendered later, has a salutary cautioning influence upon the water-rate payer. It leads him to inspect his fixtures and to stop leaks or any undue waste; but he directly benefits from this care in a better supply of water, a relatively smaller tax, and in the knowledge that he is paying his honest indebtedness to the city; and, finally, has not to pay for his neighbor's waste of water, as he did under the old system.

The meter system, in fact, is the only equitable method of selling water to the inhabitants of a city; and, its general adoption would in many cases defer the expansion of supply systems for a generation.

## THE PROPOSED NEUTRALIZATION OF THE ISTHMIAN CANAL.

Since the announcement of the abrogation of the Clayton-Bulwer treaty and the signing of a new treaty providing for the construction and control by the United States of a ship canal across the Central American isthmus, a rather surprising opposition has developed to the new treaty's ratification. The ground for this opposition, as stated by perhaps its ablest representative, is that "The American Canal Must be Ours in Fact as in Name," a sentiment which sounds well, but is not illuminating as to the actual facts of the case. More specifically, the principal objection raised to the new treaty is that in case the United States should be at war with a naval power, that power would derive as much advantage as ourselves from the use of the canal.

The new treaty, as most of our readers are doubtless aware, provides that the canal shall be neutralized by international agreement in the same manner as the Suez canal; that no act of war may be committed in it and that belligerents of any nation may make use of it, under proper restrictions. No fortifications are to be constructed, commanding the canal or its entrances, but the United States has the right to maintain "such military police as may be necessary to protect the canal against lawlessness and disorder."

We said in our issue of two weeks ago that the Administration deserves the hearty approval of all Americans, whatever their party affiliations, for its successful negotiation of the Hay-Pauncefote treaty. After carefully considering the points raised by the objectors to the treaty, our opinion remains unchanged.

It is true that on a superficial view of the matter, the apparent permission given in the treaty for vessels of an enemy to use the canal on the same terms with our own may seem like a dangerous weakening of our national defense. A more thorough study of the subject, however, must convince any fair-minded man that this is by no means the case. The facts which the opponents of the new treaty appear to have overlooked are briefly as follows:

First and chiefly, that under the conditions of modern warfare the actual objective of a hostile naval force is not the enemy's coast but his fleet. This is so important a matter and is so generally misunderstood that we shall try to make it clear.

Suppose any of the great European powers were to declare war against the United States and send

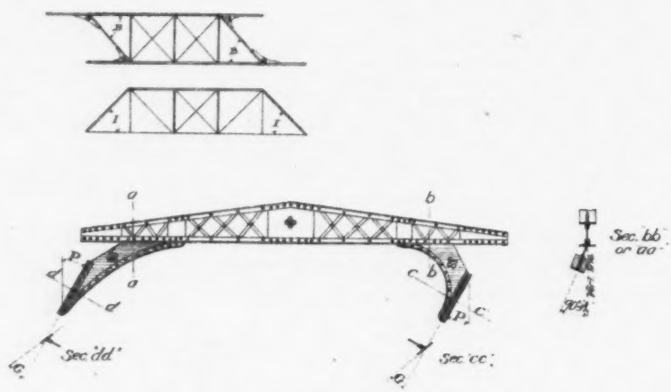


FIG. 21 HIGHWAY BRIDGE SKEW PORTAL.

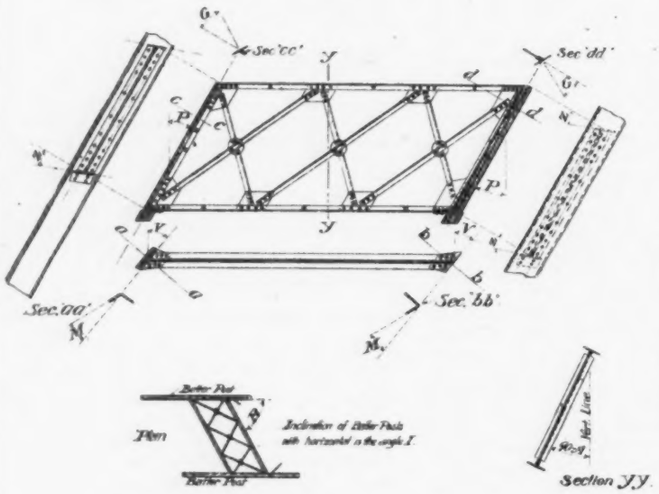


FIG. 22. SKEW BRACE FRAME FOR BRIDGE PORTALS.

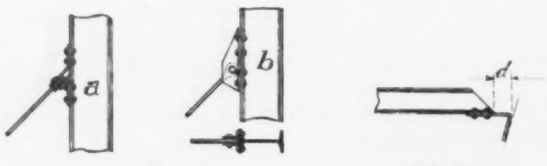

FIG. 30.



FIG. 31.

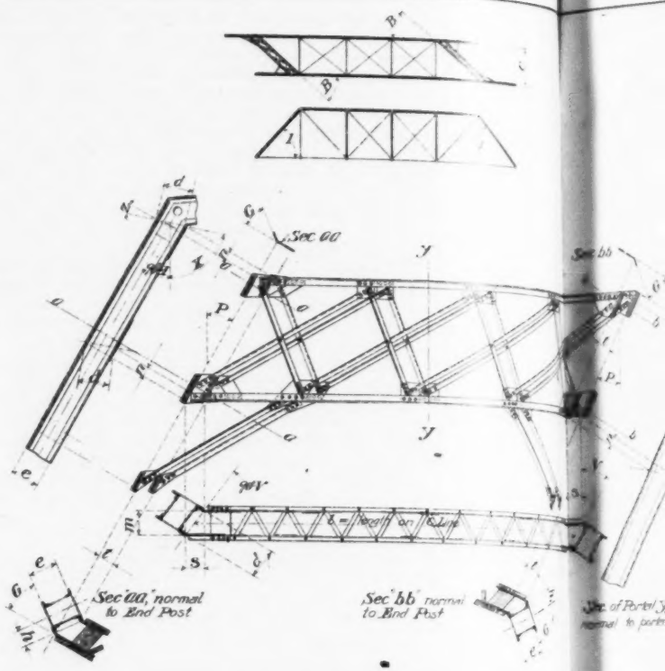


FIG. 23. BOX PORTAL FOR SKEW BRIDGE.

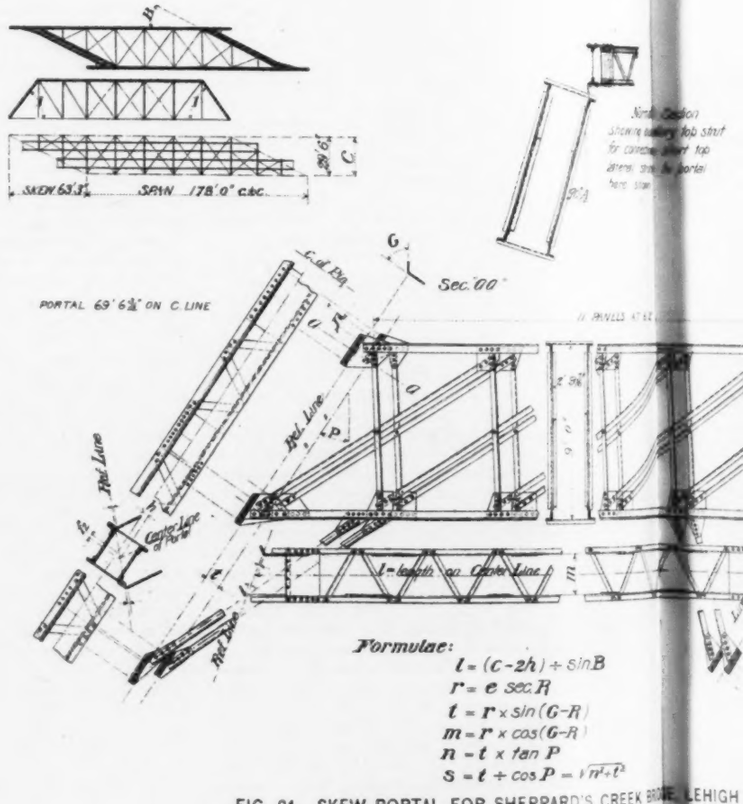
SKEW 63°3'
SPAN 178'0" c.to c.
PORTAL 69'6½" ON C. LINE
Sec. oo
Ref. Line
Center Line of Portal
l = length on Center Line
Formulae:
l = (c - 2h) ÷ sin B
r = e sec R
t = r × sin (G - R)
m = r × cos (G - R)
n = t × tan P
s = t ÷ cos P = √(n² + t²)

FIG 24. SKEW PORTAL FOR SHEPPARD'S CREEK BRIDGE, LEHIGH

## THE COMPUTATION OF SKEW DETAIL

By C. A. P. Turner, C.

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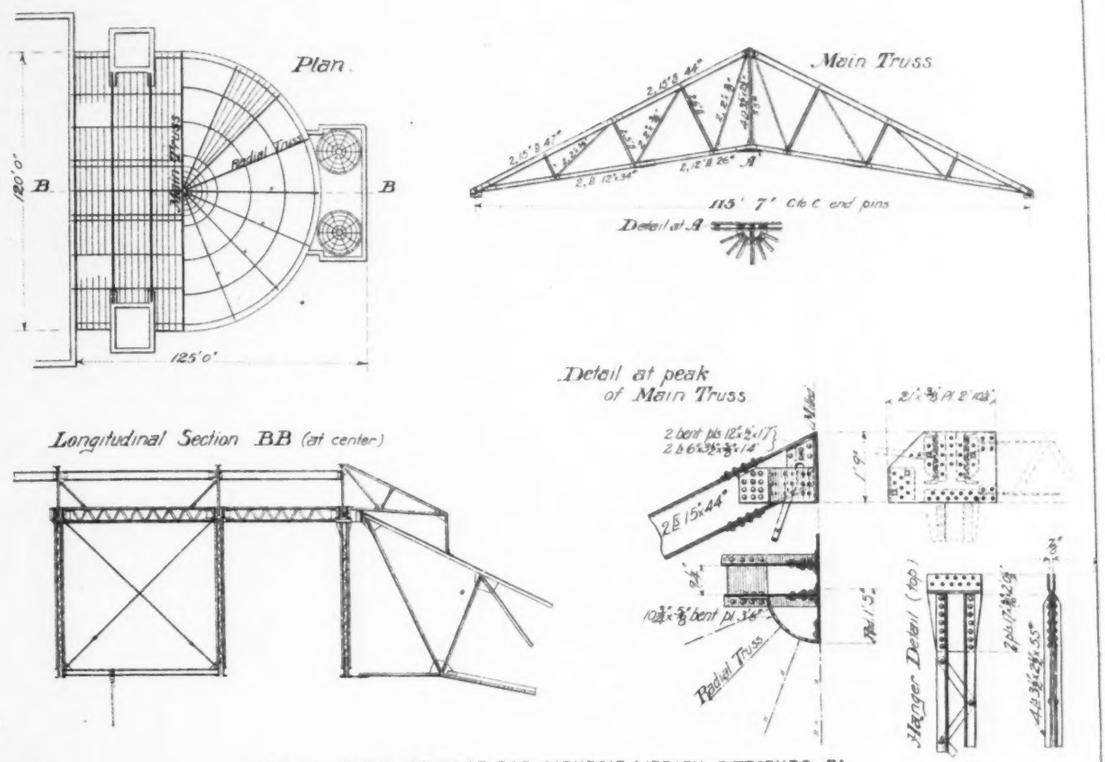



FIG. 29. DETAIL OF ROOF FOR CARNEGIE LIBRARY, PITTSBURG, PA.

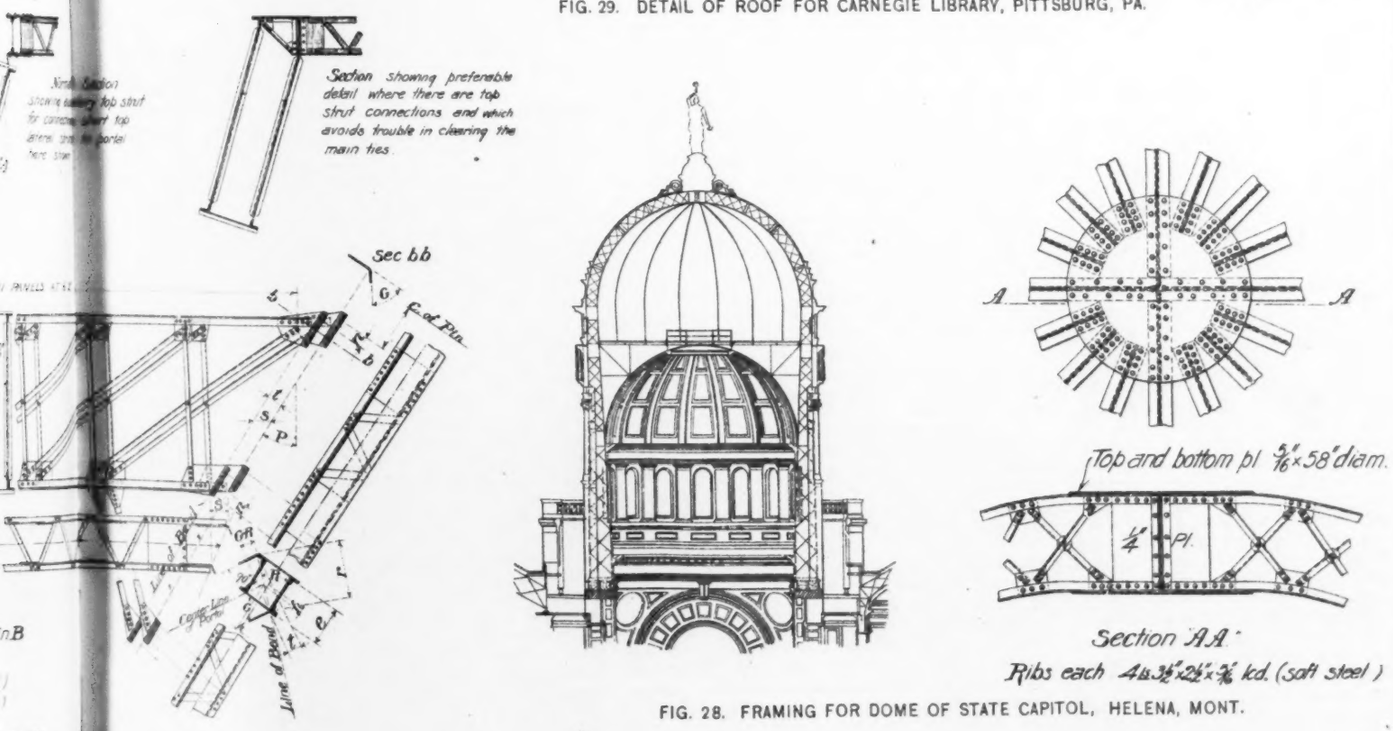

Section showing preferable detail where there are top strut connections and which avoids trouble in clearing the main ties.
Sec bb
Top and bottom pl 5/16"x58" diam.
¼" Pl.
Section AA
Ribs each 4 L 3½"x2½"x⅜" lcd. (soft steel)

FIG. 28. FRAMING FOR DOME OF STATE CAPITOL, HELENA, MONT.

S CREEK BRIDGE, LEHIGH VALLEY R. R.

OF SKEW DETAILS IN BRIDGE WORK.

C. A. P. Turner, C. E.

CHAS. HART, LITH., 98 VESEY ST., N. Y.

a hostile fleet across the Atlantic, they would endeavor first to engage and defeat the American fleets. If that were accomplished, a blockade of some of the principal seaports could be effected, and any other military movements desirable could be undertaken; but neither of these things could be done until the American naval vessels, of any formidable fighting force at least, were disposed of.

We are aware that this is not at all the popular idea of a naval attack. When Cervera's fleet came across the Atlantic two years ago, dwellers along the New England coast were in daily dread that its smoke would appear off the horizon or that they would awake in the night to hear the roar of its ten-inch guns dealing destruction to seaside hotels and bathing houses. The fact was overlooked that a coast attack would accomplish nothing whatever for the Spanish cause; and that the cost of the ammunition wasted in shelling any of the unfortified coast towns—even if that were not contrary to the customs of civilized warfare—would be much greater than all the damage done.

Neither had Cervera's fleet anything to gain by attacking the larger seaboard cities. Modern naval vessels cannot successfully attack fortified and well-mined ports. Guns which are mounted on board the moving hull of a vessel are no match for modern sea-coast artillery mounted on disappearing carriages. The mortar batteries, so largely used for coast defence, can drop their huge projectiles on the decks of vessels, where there is no armor to withstand their entrance As for the mines and torpedoes beneath the water, the most formidable battleship is so vulnerable to their attack that it would be folly to expose her to them.

For an illustration of modern naval tactics, we have the well-known fact that during the recent Spanish war not a single Cuban port of importance was captured by the American navy. The fortifications that defended them were in many cases antiquated and ineffective; the mine fields in their waters were of more than doubtful efficiency; yet the American commanders did not venture on any serious attack, because they well knew that even if successful, any such attack would inflict no damage to the enemy commensurate with the risk of serious loss to the American side.

The Spanish war also illustrates the trifling effect of naval bombardments, either of towns or of fortifications. The desultory firing upon minor coast fortifications, which was done by the blockading fleet, accomplished nothing whatever. The heavy bombardment at Santiago carried on for several days by nearly all the heaviest vessels of the American navy, did little damage to either the town of Santiago or the fortifications defending it. It was not this bombardment but the investment by the American army that finally compelled the surrender of Santiago.

These incidents of the Spanish war illustrate very well what the tactics would be of any European power, which should engage in war with the United States, and send a hostile fleet across the Atlantic. They would not risk the almost certain loss of their vessels by attacking a fortified port. They would not bombard coast villages, for this would inflict no serious injury upon their adversary. They would not even attempt to send over a military expedition until the sea power of the United States was destroyed; for a fleet of troop transports is the most vulnerable thing afloat.

The present experience of Great Britain is a revelation as to the difficulties and dangers which will beset any nation undertaking to send its troops across an ocean to engage in a campaign against an enemy of anything like equal power. No other nation in the world has anything like the equipment of troop transports and supply ships possessed by Great Britain. Yet to carry on her war against the Transvaal she has been compelled to charter additional steamships from the merchant marine to the number of 214, representing a total of over a million tons gross.

How could such a fleet be operated and protected if the power against which she was waging war had even a few fast cruisers afloat? Not even the British navy would be sufficient to protect it from attack. If such an army and such a fleet is required to wage a war against the insignificant Transvaal, on what scale would it be necessary for a European nation to proceed to make a successful military invasion of the United States? It is clear that no such thing would be even remotely possible until our navy was destroyed.

We have taken pains to explain in some detail the reasons for this axiom of modern naval warfare, for it has, as may be readily seen, a direct bearing upon the proposed neutralization of the Isthmian canal. We need not fear, as some of our newspaper alarmists have done, that such a canal would enable a hostile fleet from Europe to pass through and attack Pacific coast ports. Any hostile fleet which comes over here will have for its business the attack and destruction of the United States forces on the seas, and it will not seriously undertake anything else, until that is accomplished. If it is defeated in this attempt, the Nicaragua canal will do it no good. If it succeeds, it will not undertake a voyage of one to three thousand miles to our Pacific coast, but will immediately proceed to blockade some of the most important Atlantic seaports as the best means of bringing us to terms. If it follows this move by a military invasion (which it would be most unlikely to do) it will conduct it from some point on the Atlantic coast and would never dream of going round to the Pacific, two or three thousand miles farther from its home base.

The advantage of an isthmian canal to the United States from a military point of view, is that it will enable the nation to concentrate its naval force on either the Atlantic or Pacific, from whichever side an attack is threatened. The sole advantage which an enemy's fleet could gain from it would be the ability to effect a corresponding concentration. This, however, it is little likely to have occasion to do. It may be safely assumed that any hostile European fleet sent against the United States will be mobilized, equipped and started from a European port. Without such preparation it would be in no condition to meet the American forces after a transatlantic voyage.

The result of a start without such preparation is well shown in Admiral Cervera's melancholy account of his unfortunate expedition across the Atlantic, destined, as he realized from the beginning, to certain defeat.

But, it may be said, is it not possible that a European nation at war with us might have some of its war vessels in South American ports at the outbreak of hostilities and might not these desire to use an Isthmian canal to effect a junction with a fleet from Europe? In answer to this, it is to be said that they might desire to do so, but it is very doubtful whether they would run the risk. They would have to take the chances of meeting a superior American force, either off the Pacific entrance to the canal or during their passage through the Gulf, and the distance around the Horn is not so much greater that it would be deemed worth while to run this risk.

To sum up the case briefly, then, an enemy's fleet will seek to engage our own fleet and not to attack our coasts. The canal will assist us to concentrate our forces to meet the attack. The enemy will effect his concentrations at some point so far distant that the canal would be of no use to him, and even if it would be a convenience for some of his minor moves, passage through it would involve too many risks to make it worth attempting.

So much for the neutralization of the canal from the military point of view—which is the chief point from which the Hay-Pauncefote treaty is now attacked. Let us now turn to the other feature of the treaty which has received some criticism—that permitting its use by vessels of all nations on equal terms. This provision also, we conceive, is in the interest of the United States. If this country invests from one hundred to two hundred million dollars in a ship canal across the Central American isthmus, it will do it with the expectation and desire of making a direct profit on the transaction from the receipts from tolls. In order to do this it will invite all the nations of the world to use this new highway of commerce. Every vessel with the gold to pay its tolls should be equally welcome, whatever the flag she carries. To complicate the canal enterprise with projects for subsidizing our merchant-marine or our export trade would be in the highest degree unwise, and would be a real obstacle to its popularity.

It must be remembered that the great question of monopoly and competition in the carrying trade is important on sea as well as on land. The tendency toward consolidation and the control and limitation of competition is a matter of public agitation in many countries and will be here, as our export trade continues its rapid growth.

More and more of the traffic of the high seas is falling into the hands of great corporations, owning whole fleets of vessels, which ply back and forth regularly over the chief routes of trade. Traffic compacts and agreements for the maintenance of rates are becoming nearly as common between these corporations as between railway corporations. It is manifest, that anything which limits the field of competition increases the power of these combinations to control and increase the rates charged for ocean freight. We fully appreciate the circumstances which bring about such traffic compacts, and we call attention to them here merely to point out the importance of keeping open such other means of competition as will limit such combinations in their charges. It is for the interest of every farmer, manufacturer, or merchant who expects to derive benefit from a Nicaraguan canal, that it shall be open on equal terms to the vessels of all nations. Every tramp steamer of every nation should have equal rights to its use with the most favored corporation. Thus only can American producers be assured of the widest field of competition and the lowest rate for the carriage of their goods to a market.

And now, in conclusion, a word deserves to be said as to the new treaty from the aspect of our national policy. The United States is awakening to its destiny as the greatest manufacturing and trading nation of the earth. American producers have shown that with a fair field and no favors they can compete in the world's markets and come off victorious. We have just achieved one of the greatest triumphs ever scored by American diplomacy in securing international agreement for the "open door" in China. It would ill become us now to adopt a narrow and illiberal policy, in opening a highway between the world's two great oceans. The gift which nature bestowed on mankind, in making the neck of land which joins the two American continents so narrow that it may be pierced by human agencies, is a gift bestowed on the human race, and not on this nation alone. If we, by our enterprise, are the first to open a passage through this barrier, we may justly claim a reward from those who benefit by this highway commensurate with our risk and outlay in making it; but to seek to monopolize its use would be contrary to our highest national aspirations as well as an injury to our best interests.

Similarly in regard to the military aspects of the canal. No one can doubt that the temper of the American people is not for war, but for peace. We should be blind to recent events if we did not appreciate and prize anew the evidence that the seas which roll between us and the other great nations of the world, are a defense far stronger than all the armaments of Europe. We do not need the canal to protect us from foreign aggression. Our strength, actual and potential, is so great that we need fear no foreign foe. We have stood among the nations for the principle of arbitration instead of war; we have favored the extension of the principle of neutrality to cover all private property on the high seas in time of war. Certainly, then, it would ill become us to object to the neutralization of the canal through the Central American isthmus; and we believe that the treaty which Secretary Hay has drafted, and of which he has secured the approval of Great Britain, is favored by a great majority of the American people.

## LETTERS TO THE EDITOR.

### Recent Practice in Railway Signaling and Interlocking.

Sir: From actual observation in and about Chicago I believe that some one will have to take up the matter of signals and interlocking very vigorously, if we are to

progress rather than go backwards in that department of railway service. The average railway in the United States to-day has aimed to perfect the motive power, equipment, roadbed and track, but has sidetracked, as it were, the question of providing a perfect system of signals, to the detriment of economy and safety. Admitting that the prominent railways employ experts in signaling, the question arises: Are the ideas advanced by these experts carried out, or are signals and their workings arranged by some officer of the road who is not familiar with the fundamental principles of good signaling, and who is willing to allow a grade crossing, or other important point on the main line, to be governed by a "high ball?"

If I understand the law which governs grade crossings in Illinois, as well as in other states, a grade crossing not properly protected by an interlocked system of signals requires that trains approaching the crossing must come to a full and complete stop, and must not proceed until it is known that the crossing is clear and there is no train approaching in the opposite direction. How many times each day is this law violated? Oftentimes with officers of the road on the trains.

Knowing the necessity for perfect signals, we next come to their position, and I contend that the proper position of a signal for a main track route is directly over the track which it governs. While I was with the Pennsylvania R. R. in 1882, the question of signals came up at a meeting in Altoona, and I took exception to the practice under which this road, between New York and Philadelphia, had from four to six signals on one post. It may be admitted that during the day the position of the signals governed the routes, and the chances for mistakes were less frequent that at night, when the routes were governed by the colors of the lights displayed. With three or more signals on one post, if the lamp of the top or bottom signal were to go out, how could an engineman designate which signal was out; in fact, would he notice that any lights were extinguished where so many signals were displayed? At the time the idea was ridiculed, but I think to-day it is general practice that signals governing main line routes are on bridges over their respective tracks.

To sum the matter up, no corporation, general manager or superintendent has a right to require an engineman, more especially on a high-speed train, to be governed by a signal in any position other than in a direct line of vision parallel to the direction of the train. If not directly over the track, it should be always to the right of the engineman's side of engine. It is an unfortunate fact that we have a great many roads (double track) with trains running to the left, which places the engineman on the inside. Where the tracks are the standard distance apart, this will not allow signals to be placed between the tracks, or, in other words, to the right of the engineman. This is an English idea, and unfortunately has been installed on several American roads, although some (including the Philadelphia & Reading R. R.), after operating left-handed, have changed to the American idea, "Always keep to the right."

Signals and their workings, to my mind, will be considered and installed to a greater extent during the next few years than ever before. No dispatcher, operator, towerman or leverman is infallible. I therefore advocate automatic block signals. At crossings these signals should be properly interlocked, and all interlocking equipped with electric locking, so that after a train has been given a clear signal, the route cannot be changed until the train has passed through the interlocking.

Chicago, Ill., Feb. 15, 1900. S. S. Neff.
Superintendent, Union Elevated Ry.

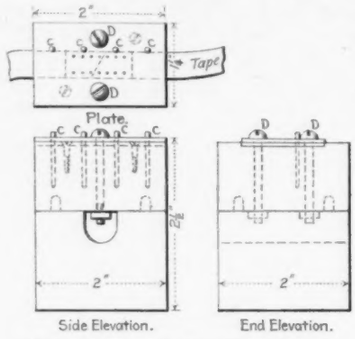
### Notes and Queries.

In reply to the inquiry of "W. W. P.," in our issue of Jan. 11, Mr. Ralph I. Tolles, Chairman of Committee on Streets and Sewers, of Plainfield, N. J., writes us that in that city the offices of City Surveyor and Street Commissioner are combined, the present incumbent, Mr. Andrew J. Gavett, having charge of all the city engineering and also all street and sewer work. The results are so satisfactory that he has just been reappointed for a term of three years.

## STEEL TAPE REPAIRING AND CLEANING DEVICES.

A broken steel tape has usually to be sent to the nearest repair shop; for the sufficient reason that the engineer generally lacks the facilities for mending it properly himself. Mr. E. F. Musson, of Norwich, N. Y., sends us a sketch of a simple device for doing this work, and making a better job of it than can be done in the average shop.

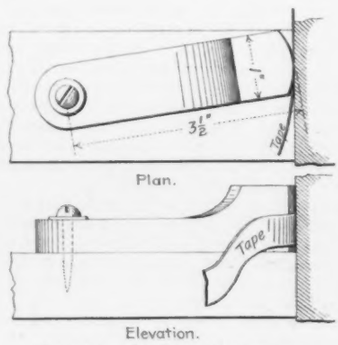
A thin steel plate, 2 × 1¼-in. by 1-16-in. thick, is fastened to the top of a wooden block by screws with countersunk heads; and above this is another plate of the same thickness. Through both of these plates a row of holes, c c c, is drilled, through which small wire nails are driven, which serve to keep the tape in line and also to hold the top-plate in position. Then through both plates two other rows of smaller holes are drilled as shown, or three or more rows if tapes of different widths are being used. These smaller holes are about the size of a large pin, which makes a convenient rivet; and the holes should be quite close




A Clamp for Mending Steel Tapes.

together and yet cover length enough to provide for any angle of break.

To repair a broken tape, it should be placed between the plates, the ends brought carefully together, and the whole then firmly secured by using the stove-bolts D. After the holes are punched, the tape should be removed and a splicing-piece put into the clamps and similiarly punched; if the punch is sufficiently strong, however, both can be punched at the same time. The riveting of the splice and tape together completes




Holder for Cleaning Steel Tapes.

the work, and perfect contact and true alinement are secured.

The tape-cleaning device shown is really a means of holding the tape while it is being cleaned in the ordinary way. When in use it can be readily clamped or screwed to a window-casing, with the moving part acting as a toggle-joint to hold the tape between it and some abutting object.

## THE PURIFICATION OF WATER BY OZONE.

A paper entitled "The Ozonation of Water" was read on Feb. 14, by Dr. George A. Soper, of New York city, before the New England Water-Works Association. The paper was, in substance, nearly identical with the one published by Dr. Soper in Engineering News, of Oct. 19, 1899, but as this is the first time a paper on this subject has been read before any technical society in this country, the discussion raised by it brought out a number of points of interest.

Mr. Leonard P. Kinnicutt, Professor of Chemistry in the Worcester Polytechnic Institute, after discussing the general results, spoke upon the possibility of producing ozone much more cheaply within the next 10 or 15 years, and mentioned the new method of obtaining it by adding fluorine gas to water. It is claimed that in this way air containing about 15% of ozone can be procured.

In answer to a question by Dr. F. S. Hollis, Dr. Soper stated that the amount of air required was 1 cu. ft. for 25 gallons of water—enough so that the aeration would doubtless remove a part of the odor if air were used which had not been ozonized.

Mr. H. W. Clark, Chemist of the Massachusetts State Board of Health, said he understood from the account in Engineering News of February 8, 1900, that in the discussion of Dr. Th. Weyl's paper before the German Society of Gas and Water Works Engineers, Mr. Halbertsma had said that the plants for ozone treatment of water, both in Holland and at Paris were experimental only. This seems to conflict with Dr. Soper's account. Further, in Dr. Soper's own experiments he found he could remove 85% of color artificially produced, but removed only 35% of the color from Croton water. Dr. Soper said in explanation that the discussion before the German Society was unfortunate in that the water-works engineers who knew that their filters were doing good work felt called upon to refute the statements of Dr. Weyl that a filter was a menace to the public health. What Mr. Halbertsma actually said was that there was no plant in Holland treating water by ozone on a commercial scale. This is true, for the plant at Oudshoorn is experimental only and that at Blankensberg, which is on a commercial scale, is in Belgium. The plant at Paris to which he referred seems to be the experimental installation at the Hygienic Exhibition. The one now in operation is considerably larger than that at Blankensberg, and treats over 3,000,000 gallons daily. It treats the effluent from English filters which are poorly operated. Unfortunately there is no information as to how much purification is effected by the filters themselves. The 35% of color removed from the Croton water was done when operating under conditions which would be practicable, while the 85% reduction was obtained in an attempt to remove as much color as possible without regard to economy.

In reply to questions by Mr. Horatio N. Parker, Dr. Soper said that water was not a solvent for ozone, and did not retain it. The treated water produced no ill effects upon the human system. If germs were put into water which had been ozonized they would probably thrive as well as in water not so treated, at no permanent germicidal qualities are imparted to the water. Regarding what Mr. Halbertsma had called the "churchyard of bacteria bodies," he said this could not exist, as the action of the ozone was one of combustion and the bacteria would, therefore, be oxidized to harmless mineral compounds. It is also destructive to the ptomaines resulting from bacterial action, as was shown at Oudshoorn by an experiment with the toxin of tetanus. After diluting it to 1-50 strength, ½ cu. cm. was injected into a mouse, which died. Other portions of the toxin were treated with ozone for ten minutes, after which 1 and 2 cu. cm., and even more, were injected into mice without ill effects. It is necessary to remove the larger masses from the water before ozonization by preliminary filtration or straining, as otherwise the power of the gas would be used up on these matters. This method would, perhaps, be especially applicable to the effluent of a filter which was giving unsatisfactory results either because overworked or because improperly operated.

THE PROPOSED NEW WATER AND SEWERAGE systems for New Orleans involve a large amount of work, including careful studies of water purification and sewage disposal. Pumping plants will be required for both the water and sewerage systems. Mr. Geo. Earl, who was recently appointed as general superintendent of the board of water and sewerage commissioners, has just made a preliminary report to the board in the nature of a general review of the situation. He advises that an advisory board should include at least three men, one to be the most eminent civil engineer in the United States engaged in waterworks and sewerage practice, one to be "that special student of water filtration who has had the opportunity to study the problems nearest allied to those here involved," and the third "that home engineer who, from local knowledge, mature and wide experience and fair deliberate judgment would command the greatest respect in New Orleans." He also suggests the appointment of three assistant engineers and two or more draftsmen to compile local information bearing on the design of water and sewerage systems, preference to be given to men who have had "actual experience in connection with excavations in the thickly settled portion of New Orleans."

## LEGAL DECISIONS OF INTEREST TO ENGINEERS.

Reported for Engineering News by Andrews & Murdoch, Berrien Springs, Mich.

### Right to Grant Franchises.

In the absence of legislative grant, a city has no power by contract or ordinance to confer the right to obstruct its streets, or to grant franchises and privileges in the same that tend to impair the public uses for which they were dedicated and intended.—City of Mobile vs. Louisville & N. R. Co., 26 So. Rep. (Ala.) 902.

### Discrepancy Between Plat and Minutes of Survey.

A plat of a city, as originally laid out, which was recorded and by reference to which conveyances were made, showed that a particular lot at the intersection of two streets was not rectangular, but that the exterior corner had been taken off, and added to the width of one of the streets. The minutes of the original survey contained a statement of the width of the streets, without showing that it was of uniform width throughout, as in fact it was, as shown by the plat. Held, that the plat and minutes were not inconsistent, but, that, even if contradictory, the plat would control as to the boundary of the lot, where it was the settled policy of the state, as shown by the statutes, to require the recording of plats of cities and towns.—City of Cleveland vs. Bigelow et al., 98 Fed. Rep. (U. S.) 242.

## METRIC CONTRACTIONS.

With the growing use of metric measures in this country, there is a very considerable diversity in the contractions employed. The Paris Conference of 1881 officially adopted a system of contractions which is still in force, and in the interest of uniformity this table is here given. The conference ruled that italic figures should be employed to designate these contractions, and that no stop should be placed to the right of them; the contractions were to follow the figures they referred to, and were to be placed after the last decimal, when decimals are used. The following table is taken from "Molesworth's Metrical Tables," though the italics are not used and the decimal is employed:

**Length.**

km. = kilometer.
m. = meter.
dm. = decimeter.
cm. = centimeter.
mm. = millimeter.

**Weight.**

t. = tonne = 1,000 kg.
q. = quintal = 100 kg.
kg. = kilogramme.
dkg. = decagramme.
g. = gramme.
dg. = decigramme.
cg. = centigramme.
mg. = milligramme.

**Surface.**

$km.^2$ = sq. kilometer.
$m.^2$ = " meter.
$dm.^2$ = " decimeter.
$cm.^2$ = " centimeter.
$mm.^2$ = " millimeter.
ha. = hectare.
a. = are.

**Solidity, Etc.**

$km.^3$ = cubic kilometer.
$m.^3$ = " meter.
$dm.^3$ = " decimeter
$cm.^3$ = " centimeter.
$mm.^3$ = " millimeter.

**Capacity.**

hl. = hectoliter.
dl. = deciliter.
l. = liter.
cl. = centiliter.

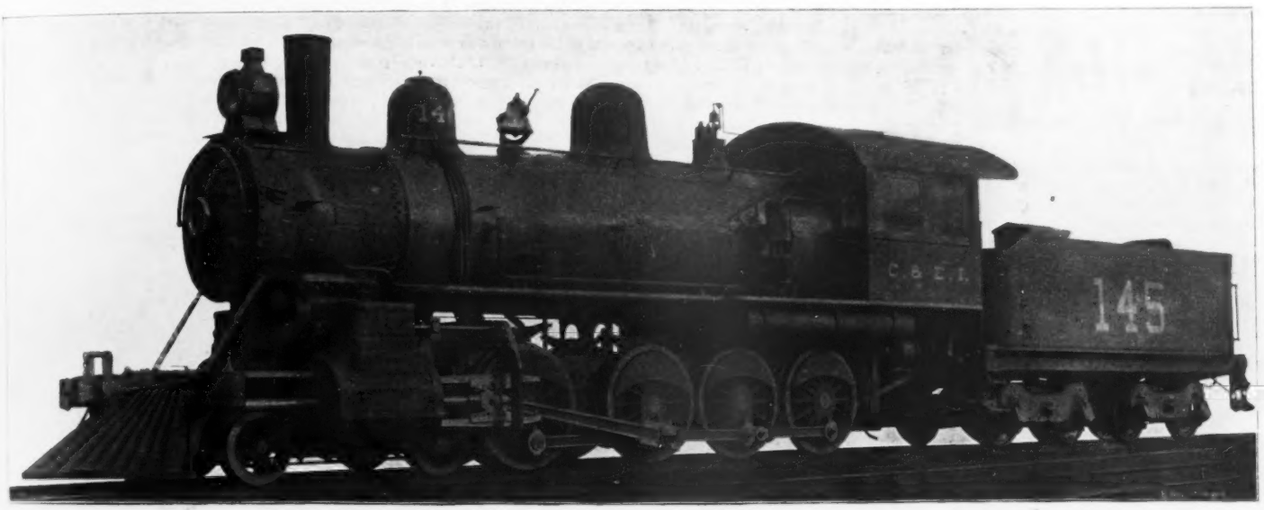
## TWELVE-WHEEL COMPOUND LOCOMOTIVE; CHICAGO & EASTERN ILLINOIS R.R.

We illustrate herewith a heavy freight locomotive, recently built by the Pittsburg Locomotive Works for the Chicago & Eastern Illinois R. R. The lines of this company extend from Chicago southward to the coal fields of western Indiana and eastern Illinois and also southward to the coal fields of southern Illinois in the Carbondale district. The system has consequently a very heavy coal traffic. Its total freight tonnage in 1898 was nearly 5,000,000 tons. To handle this traffic with economy and place the product on the market at prices which will compare with the coal from other Illinois fields and with coal brought by water, heavy train loads are essential.

The 12-wheel locomotive which has just been built for the company is not a record breaker in size, although it would have been a very few years ago. It is at present merely a sample of the huge machines which are now "standard practice" on all American railways of heavy traffic, and which are creating a revolution in lowering the cost of transporting bulk freights by rail. As seen by the engraving, the engine is a two-cylinder compound. The low-pressure cylinder is 33 ins. in diameter and its jacket has been made flat on its outer side to bring it within the clearance limit. The piston rod is carried through the front cylinder head, to help support the heavy piston, according to the practice now common in large locomotives. The very long wheel base of the front truck is a noticeable feature, and was necessary, apparently, to get the truck wheels out of the way of the big low-pressure cylinder. The crowding of details about the front driver of the locomotive is noticeable, and gives one much respect for the draftsman who succeeded in assembling all the various parts in the narrow limits available without having them interfere with each other. This, however, is what the designers of modern huge locomotives are all the time wrestling with; and the ingenuity which is exercised by the draftsmen in locomotive building shops and railway motive power offices in getting inside the fixed limits of space the enlarged details of modern large-sized locomotives is something which deserves more appreciation than it receives. It is successful work of this sort that has made possible such huge machines as that illustrated herewith and has made possible also the great saving which these have made in the cost of rail transportation.

We are indebted to Mr. D. A. Wightman, General Manager of the Pittsburg Locomotive Works, for the photograph of the locomotive from which our engraving is reproduced, and also for the following table showing the principal dimensions of the machine:

| | |
|---|---|
| Total weight of engine in working order | 182,200 lbs. |
| " " " " on drivers | 144,000 " |
| Driving wheel base of engine | 15 ft. 6 ins. |
| Total " " " " | 26 " 2 " |
| " " " " " and tender | 54 " 6 " |
| Height from rail to top of stack | 14 " 9¾ " |
| Cylinders, high pressure, diameter and stroke | 21½ x 30 " |
| " low " " " " | 33 x 30 " |
| Slide valves | American Balance |
| Piston rods | Cambria steel, 4 ins. diam. |
| Type of boiler | Extended wagon top |
| Diameter of boiler at smallest ring | 64 ins. |
| " " " " back head | 72 " |
| Crown sheet supported by radial stays, 1¼-in. diam. | |
| Stay bolts, 1-in. diam., spaced about 4-in. centers | |
| Number of tubes | 288 |
| Diameter " " | 2 ins. |
| Length of tubes over tube sheets | 13 ft. 6 " |
| " " firebox, inside | 126 " |
| Width " " " | 41 " |
| Working pressure | 200 lbs. |
| Kind of grates | Cast iron, rocking |
| Grate area | 36 sq. ft. |
| Heating surface in tubes | 2,081 " " |
| " " " firebox | 192 " " |
| Total heating surface | 2,273 " " |
| Diameter of driving wheels, outside of tire | 54 ins. |
| " and length of journals | 8½ x 10 " |
| " of truck wheels | 28 " |
| " and length of journals | 5 x 10 " |
| Type of tank | Level top |
| Capacity of tank, water | 4,500 U. S. gallons |
| " " " fuel | 320 cu. ft. |
| Weight of tender with fuel and water | 93,000 lbs. |
| Type of brake | Westinghouse American |




TWELVE-WHEEL COMPOUND LOCOMOTIVE FOR THE CHICAGO & EASTERN ILLINOIS R. R.
T. A. Lawes, Supt. of Motive Power.
Pittsburg Locomotive Works, Builders.

## NOTES FROM THE ENGINEERING SCHOOLS.

Massachusetts Institute of Technology.—The new catalogue of 360 pages gives a full register of graduates and their professional occupations. A study of this register brings out the interesting fact that of the 2,136 graduates, since 1863, one-half have taken their degrees in the past seven years. The Washington Society of the Massachusetts Institute of Technology is a new alumni society formed, with Mr. Frederick H. Newell, '85, Chief Hydrographer of the U. S. Geological Survey, as President. Two additional courses are announced, on Heating and Ventilation and on Landscape Architecture. The catalogue gives a long list of appointments made in the last year from the graduates of the Institute. The position of President of the Institute, to succeed President Crafts, resigned, has been offered to Capt. Alfred T. Mahan, U. S. N.; but has been declined on the ground of age and a fear that he would be less useful to the Institute than in his present position.

Harvard College.—The annual report of the President, for 1898-99, treats largely of the new scheme of requirements for admission to Harvard College and the Lawrence Scientific School adopted by the Faculty of Arts and Sciences on May 16, 1899, after a discussion lasting three years. This new plan proposes to bring the college into closer connection with the high schools throughout the country, and tends to enlarge the election of studies in all secondary schools. By its regulations, a student, 16 or 17 years of age before deciding to go to college, can have count towards his admission most of the studies already pur-

sued in a good secondary school, and he will only have to add in the later years of his school course two or three subjects he had before neglected. The new scheme also permits a free option for Greek, instead of the restricted option in force for many years. A modern language, ancient or modern history, or any one scientific subject from a considerable group, may be presented instead of Greek. The Lawrence Scientific School, besides counting for admission all the subjects permitted for admission to Harvard College, will also count shopwork and drawing, botany and zoology.

A modified plan for retiring allowances for professors and assistant professors was adopted on March 27, 1899, marking a new epoch for university officials in the United States. These regulations are printed in full in the report; but the main features are as follows: Any person who has been a professor or assistant professor for twenty years, and has reached the age of 60 years, may, if he please, retire on an allowance of one-third of his last annual active salary; with an additional allowance of one-sixtieth of this salary for each year of service exceeding twenty; provided, that no retiring allowance shall exceed two-thirds of the last active annual salary. The President and Fellows, at their discretion, may retire wholly or in part any professor who has reached the age of 66.

The cost of wholesome board in Cambridge has been somewhat reduced. The Dining Hall Association now feeds about 1,150 students in Memorial Hall, at an average of about $4 per week. The new Randall Dining Hall feeds 800 students on the restaurant plan, at an average cost of $2.75 to $3.00 per week. At Cambridge clubs and boarding houses meals cost from $5 to $8 per week.

The gifts to the college in 1898-99, for forming new funds or increasing old ones, amounted to the extraordinary sum of $1,383,460.

The University of Illinois.—An engineering supplement to "The State University Bulletin," calls attention to the buildings, laboratories and workshops connected with the engineering department of this institution. These structures are costly, and are thoroughly equipped with apparatus for use in connection with electrical, mechanical, railway mechanical, architectural and civil engineering instruction. These are explained in detail in the bulletin referred to.

University of Wisconsin.—A non-resident lecture course has been arranged for the college year of 1899-1900, with the following lecturers and subjects: "The Hydraulics of the Great Lakes," Jan. 19, C. B. Stewart, U. S. Asst. Engineer; "Engineering Schools and Industrial Progress in Germany," Jan. 26, B. A. Behrend, E. E.; "The Engineers and the Railroads," Feb. 16, Col. H. G. Prout, New York, Editor R. R. Gazette; "The Manufacture of Portland Cement," Feb. 23, R. C. Carpenter, Prof. of Experimental Engineering at Cornell University; "The Chemical Engineer," March 9, Magnus Swenson, Manufacturer, Chicago; Illustrated lecture on "Mexico," March 2, W. J. Karner, Asst. to Chf. Engr. Ill. Centr. Ry.; Chicago; "The Water Supply of Rockford, Ill.," March 16, D. W. Mead, Consulting Engineer; "The Government Work in the St. Paul District," March 23, A. O. Powell, U. S. Asst. Engineer; "Three-phase Railway Work," April 6, W. B. Potter, Engr. Ry. Dept. Gen. Elec. Co., Schenectady, New York; "Mechanical Ventilation and Heating," April 20, W. B. Snow, of the B. F. Sturtevant Co., of Boston; "An Educational Course for the Railway Service," April 27, George B. Leighton, Pres. Los Angeles Terminal Ry., St. Louis, Mo.

University of Pennsylvania.—Mr. F. H. Newell, Chief Hydrographer, U. S. Geological Survey, addressed the civil engineering students, on Feb. 8, on the "Water Storage on Gila River, Arizona." The next lecture by a non-resident engineer will be given on March 2, by Mr. G. I. Bailey, Superintendent of the water-works at Albany, N. Y. His subject will be "The Albany Water Supply and Filtration Plant."

The University of Michigan.—The faculty of the University for the current years numbers 233 persons; of whom 58 are professors, 56 instructors and 52 demonstrators. The bulletin notes 69 Japanese students entered since 1872, and of these 41 were graduated, 32 going from the law department.

The University of Tennessee.—"The Record," published by the University press, for October, 1899, contains a long illustrated article by Prof. G. R. McCall, on "The Electric Transmission of Power in the University of Tennessee," showing how the new shops and laboratories are operated.

University of Illinois.—This institution shows, in a series of excellent half-tone engravings, its buildings, class-rooms, library, machine shop, heating plant, electric plant, etc. There is no text issued with these illustrations, but the photographic work was done by Department of Photography, of the University. To obtain this set address the Registrar, Mr. W. L. Pillsbury, Champaign, Ill.

## FLOOD DAMAGES TO THE HUDSON RIVER PASSENGER BRIDGE AND STATION OF THE DELAWARE & HUDSON RY., AT ALBANY, N. Y.

The heaviest freshet on the upper Hudson River since 1857 occurred on Feb. 13 and 14, as the result of the hard rains of these and the preceding few days. According to the newspaper reports some $500,000 of damage was done to property along the Albany river front which was overflowed so as to drive people from their business and homes. As an indication of the extent of the freshet it may be stated that the Delaware & Hudson Ry. passenger station at Albany was flooded with a depth of over 10 ft. of water over the railway tracks. Fig. 1 is a view of the partly submerged station on Feb. 14, when the water was about at its maximum height of about 20 ft. above the mean low water level of the river. The waters reached their highest stage at 7 a. m. on Feb. 14. At 4.45 p. m. on Feb. 13 the ice broke up and partly wrecked the falsework supporting the tracks of the Hudson River Passenger Bridge during the reconstruction of the draw span. Figs. 2, 3 and 4 are views of the flood at the bridge before and after the wreck.

The passenger bridge consists of four 181-ft. fixed spans and a 270-ft. draw span over the main river and seven spans of plate girders 7 ft. deep and 72 ft. long over the basin. The A. & P. Roberts Co. have the contract for the reconstruction. Work was commenced on the falsework for the fixed spans in May, 1899. The fixed spans were completed and the falsework removed by Dec. 18, 1899. The basin spans are complete, but the falsework still remains. Piling for falsework of the draw span was commenced Dec. 21, 1899, and completed Jan. 4, 1900. The trusses of the old draw and the machinery were removed by Jan. 20, when the masonry work of the draw pier began. This masonry was completed Feb. 7, and work on the iron of draw commenced. On Feb. 11 the drum and tower of the draw were in place.

By the terms of the contract the contractors are to maintain the tracks of the railway during the renewal of the bridge. In order to do this the old trusses were removed, the old floor system resting directly on the falsework until it was replaced by the new. The uncertainty of the weather coupled with the fact that a break up of the ice in Jan. 21 severely damaged the falsework in the westerly half of the draw, prevented the floor system of the new bridge being put in. There was 11 ft. 6-in flood on Feb. 9, which further delayed the work. An ice jam three miles above the site of the bridge and the cold wave of Feb. 11, however, prevented a breaking up of the ice at that time.

The falsework consisted of pile bents spaced about 15 ft. c. to c., ten piles per bent, driven to an average of 8 ft. penetration, capped with 12×14-in. timber, upon which stood 12 ft. trestle bents made of 12×12-in. posts and caps. Both pile bents and trestles were double X, braced with 4×10-in. timbers. On the trestle bents rested three 8×16-in. yellow pine stringers under each rail.

As an extra protection for the draw span, a line of piles was driven from the up-stream fender pier to each rest pier, and the space between this line and the crib work of the draw pier was driven full of piles on about 10 ft. centers. Seventy-five piles were used on each side for this purpose, all being tied together and braced by heavy timbers. The plan of the falsework thus presented a V-shaped mass of piles, with its point at the up-stream fender, and its base setting on the rest piers.

The natural channel of the river is about 175 ft. west of the westerly rest pier. The westerly half of the draw span only is used for traffic, it not being possible to maintain more than a 6-ft. or 8-ft. channel on the easterly side. The break up of the ice on Jan. 21 completely broke off or pulled up all the fender piles in the westerly half of the draw, but did no damage to the other side. A large floe of ice from this break up piled up where the piles were and formed an ice wedge which lay on the bottom of the river and formed an excellent fender for this portion of the falsework. After this freshet, there were strung on either side over the top of the ice, wire cables attached to the falsework and carried around the up-stream fender. Early on the day of Feb. 13 it became apparent that the ice would break and such extra precautions as were possible were taken. A channel some 200 ft. in length was cut along the edge of the former ice floe to give the ice a wearing surface and tend to shove it away from the draw span.

The engineer expected to see the westerly half

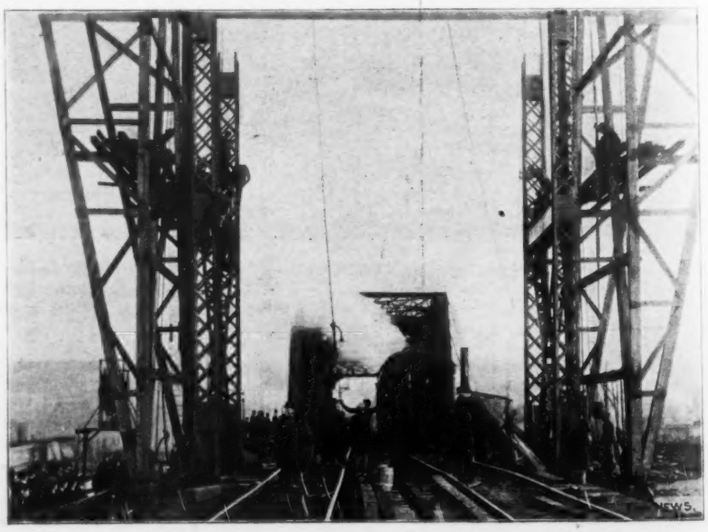


FIG. 3.—VIEW SHOWING PARTLY ERECTED TOWER OF DRAW SPAN, WITH TRAVELER BEING LASHED TO IT FOR SAFETY.

of the falsework go upon the first movement of the ice as it had been severely strained by the former break up, and had no fender piles to protect it and was on the side next the main channel where the body of the ice would naturally flow. The ice moved in the west side of the river at 4.45 p. m. and pushed against the ice floe and pushed that side down stream about 18 ins. The wire cables took a strain and held for some five minutes, when the easterly side started, moving the falsework on that side slightly. The ice had all broken by this time, and it was thought that the great danger was passed. About 4.55 p. m. the ice seemed to turn from the main channel of the river toward the easterly side and immediately that entire half of the falsework was carried out. It grounded

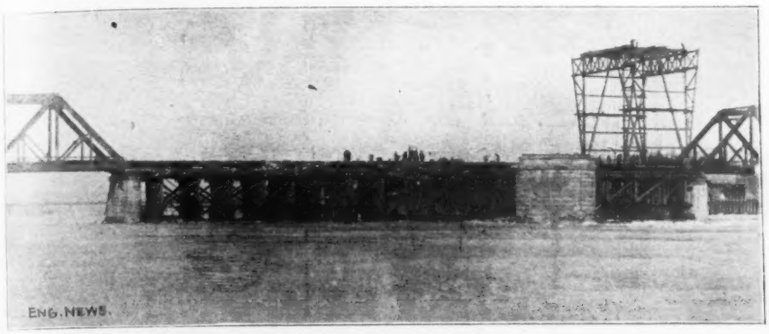



FIG. 2.—VIEW OF FALSEWORKS FOR DRAW SPAN OF DELAWARE & HUDSON R. R. BRIDGE BEFORE PARTIAL DESTRUCTION BY HIGH WATER OF FEB. 13, 1900.
(The portion of the falseworks on which the traveler is shown standing was carried away by the high water and ice.)

about 300 ft. south of the bridge where it rested until about 8.00 a. m. on Feb. 15, when the breaking of an ice jam below carried it down the river.

The water registered about 12 ft. above mean low water when the falsework was carried away. It continued to rise until it registered 20 ft. above, yet the half of the falsework that was admitted to be the weakest and which all expected to see go first, it being nearest the main channel, still stands, having settled about 9 ins. and moved down stream about 18 ins., the effect of the first shock. The only explanation of this seems to be that the ice jam of the former break up proved a better fender than the one prepared, especially for that purpose. Steps were taken at once to secure more piles, and in ten days trains are expected to be running over the bridge again. All traffic is now confined to the freight bridge, located about half a mile farther up the river.

We are indebted to Mr. J. M. Evans, C. E., for the photographs and information from which this description has been prepared.

## CEMENT-LINED SERVICE PIPE AND LEAD POISONING FROM LEAD PIPE.

At the February meeting of the New England Water-Works Association, a paper on "Cement-Lined Service Pipe, with a brief discussion of lead poisoning resulting from use of lead for service pipe," was read by Mr. Fayette F. Forbes, C. E., Superintendent of the Brookline Water-Works. It elicited considerable discussion.

Mr. Forbes said that iron pipe, protected in some way, and lead pipe, are practically the only kinds available for services. The use of lead pipe he considered unwise on account of the possibility of lead poisoning. The principal methods of protecting iron pipe are by linings of lead, tin, and cement. Any other linings or protective coatings are at the best of doubtful value. Lead-lined iron pipe is open to the same objection as lead pipe. Even if no trouble results at first, it may become necessary to change the source of supply, and the new water may dissolve the lead. Tin-lined pipe is very expensive.

In an experience of 25 years with cement-lined service pipe, not a single one has failed to deliver the required quantity of water. The only requisite for the successful use of such pipe is care and skill in lining. To begin with, the pipe is bought under specifications calling for 16-ft. lengths, and standard weight. No difficulty is found in obtaining the pipe, and the cost is not increased. The pipe is examined to see that it is straight and that there are no defects, and the coupling is removed and screwed on the other end, to make sure that the threads are in good order.

Before lining a piece of pipe 12 or 18 ins. long is screwed to each end so that the lining at the ends shall be as good as elsewhere. Neat cement is used. There are particles enough of unburned rock in the cement to render sand unnecessary. American natural cement gives the best results, the F. O. Norton brand has been used in Brookline. Portland cement is too heavy, and generally also too quick-setting. The cement should be sifted, to remove pieces of paper, sticks, etc., and perhaps some of the coarsest particles. It is best to have one man who does nothing but mix cement.

The outfit for forming the cement lining, as used in Brookline, is made by the Union Water Meter Co. The pipe is first filled entirely full of cement, and then the cone is drawn through twice; meanwhile the pipe is slowly revolved, in order to keep the cones in the center. The cones are thoroughly washed after each pipe is lined. A thin grout of cement is then run into the pipe and a rubber cone is drawn through, to get the smoothest possible surface. The short pieces of pipe are then removed from the ends and the lining reamed out to fit the composition ferules, to be described later. One barrel of cement will line 700 ft. of 1-in. pipe, 500 ft. of 1¼-in., or 300 ft. of 2-in. pipe. The clear diameter of a 1-in. pipe after lining is about ¾-in., and this is the pipe used for ordinary services.

A ferule of the best steam metal is used at the joints to prevent the water from coming in contact with the couplings. These ferules have tapered ends, and in screwing up the coupling are forced tightly against the reamed part of the cement lining. They have given perfect satisfaction. At sidewalk cocks, etc., a ferule tapered at one end is used.

To obtain the flexibility necessary in case of settlement, these pipes are joined to the main by a short piece of lead pipe.

In 1898, 3,000 ft. of 2-in. and 9,000 ft. of 1-in. pipe were lined. The cost was as follows: Labor, $69.75; cementing, $66.66; grouting, $22.66; reaming, $39.98; 23 lbs. cement at $1.10, $25.30; coal, $6.00; total, $230.35. Reduced to cost per foot, this is 3.2 cts. for the 2-in. and 1.5 cts. for the 1-in. pipe. Six men are required, and they can line from 400 to 500 ft. of 1-in. pipe per day. The total cost of 1-in. cement-lined pipe (¾-in. clear diameter) is 8.2 cts. per foot, while ¾-in. galvanized iron pipe now costs 8.0 cts. per ft.

Mr. Forbes then spoke briefly on poisoning resulting from the use of lead service pipes, refering particularly to the recent investigations of the Massachusetts State Board of Health (see Eng. News, Jan. 4, 1900).

The discussion which followed seemed to show that a number of the superintendents distrusted cement-lined service pipes almost as much as cement-lined mains and brought forward experiences quite opposite to those of Mr. Forbes. Mr. George F. Chace, Superintendent of the Taunton Water-Works, said that cement-lined service pipes had been used in Taunton since 1876, and that during the past year there were 119 complaints from such services, where the pipes had to

FIG. 1.—VIEW OF PARTLY SUBMERGED PASSENGER STATION OF DELAWARE & HUDSON R. R., AT ALBANY, N. Y., DURING HIGH WATER OF FEB. 14, 1900.
(The depth of water over the tracks is about 10 ft.)

FIG. 4.—VIEW SHOWING FENDER PILES DRIVEN TO PROTECT FALSEWORKS OF DRAW SPAN FROM DAMAGE BY MOVEMENT OF ICE.

be taken up. The trouble was in the fittings. Composition ferules were not used. Mr. Geo. A. Stacy, Superintendent of the Marlborough Water-Works, said that his pipes had rusted away from the outside, while the cement lining was still in good order. Mr. Geo. E. Winslow, suggested that these pipes might have been of steel, which corrodes much more rapidly than iron. Mr. E. A. W. Hammatt put a cement-lined pipe in the interior of his own house 16 years ago, and has had no trouble since. Mr. E. C. Brooks, Superintendent of the Cambridge Water-Works, mentioned that service pipes were frequently stopped by tubercles on the inside of the main covering the corporation cock. Mr. Byron I. Cook, Superintendent of the Woonsocket Water-Works, said that if pains were taken to screw the corporation cock through the main so as to project ½-in. or more inside there would be no trouble of that kind.

Mr. H. W. Clark, Chemist of the Massachusetts State Board of Health, said that lead poisoning was no new thing. Galen and others of the ancients stated that the use of water drawn through lead pipes would endanger health. A number of noted cases of lead poisoning were mentioned, and particularly the attempts to prevent water from dissolving lead. For this purpose water has been hardened in some places and softened in others, but the only cases that were even partially successful were when the water was hardened by the addition of carbonate of lime, or some similar substance.

## AN INTERESTING EXAMPLE OF A MODERN BLUE PRINTING ROOM.

Comparatively few people, probably, outside of those directly interested, realize the important part played by the blue print in the successful operation of a large modern manufacturing and engineering works. It is not an uncommon thing for a large structural steel works, for example, to make from eight to twelve blue print copies of every drawing, for distribution among the different shops in which the work is actually carried out, and as some large jobs require a score or more of separate drawings it is evident that the task of producing the blue prints merely is one of considerable magnitude. This fact has led most large engineering establishments to build special rooms and to place them in charge of skilled men for doing their blue printing. Some of these blue printing rooms are naturally somewhat makeshift affairs, but this is not usually the case and, indeed, in many cases they are specially constructed and fitted for the purpose at a considerable expense. The accompanying illustrations show an example of one of these more elaborate and expensive blue printing rooms, which has been recently built at the works of the Brown Hoisting & Conveying Machine Co., at Cleveland, O.

The arrangement of the office and shops of this firm made it somewhat difficult to decide upon a suitable place for the new frames. It was finally determined to run a gallery out from the fourth floor of the office building to the roof of the adjoining shop, as shown in Fig. 1, with the printing frames on one side only. The gallery is located due east and west so that the sun will shine on the frames continuously during daylight, as in this latitude the sun is always on the south side of an east and west line. There are twelve large frames, taking prints 24×36 ins. When larger drawings are made they are traced in sections so that all large tracings are the same size. A tracing made larger than about 24×36 ins. soon becomes so badly wrinkled and creased that it cannot be printed with any satisfaction, and as most of the tracings made in the office are likely to be used on future work it was decided to make 24×36 ins. the maximum size.

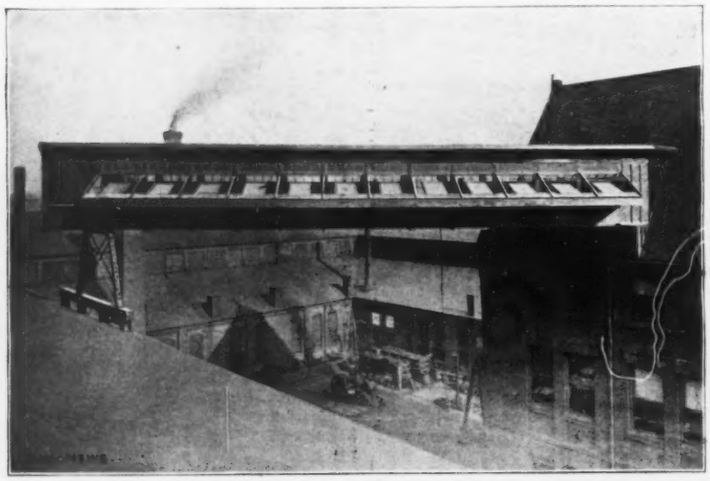


FIG. 1.—EXTERIOR VIEW OF BLUE PRINTING ROOM: BROWN HOISTING AND CONVEYING MACHINE CO., CLEVELAND, O.

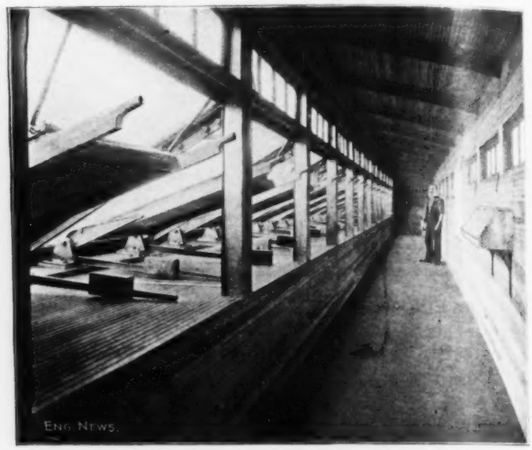


FIG. 2.—INTERIOR VIEW OF BLUE PRINTING ROOM: BROWN HOISTING AND CONVEYING MACHINE CO.

It will be seen from the illustrations that there are two glasses, the outer one forming a roof over the triangular extension at the side of the gallery. The frames are placed in this triangular space and the glass roof allows the printing to be carried on in rainy weather without interruption and with safety to the tracings. The glasses in the roof are considerably larger than the frames themselves, and this insures the sun reaching the tracings,

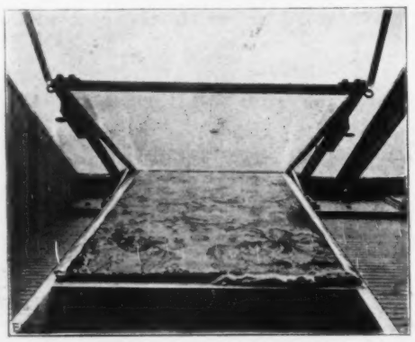


Fig. 3.—Enlarged View of Blue Printing Frame and Mounting; Brown Hoisting and Conveying Machine Co.

without shadows, at all times of the day. It also allows the space between the frames to be used in printing small tracings. About 50 prints of standard small sheets 9×12 ins. can be taken at once, in these spaces. The printing of photographs is also done in these spaces. No frames are used in printing small tracings, the tracing and paper being laid upon a pad made of blotting paper and a heavy glass laid on top. The weight of the glass is sufficient to give good contact.

Figs. 2 and 3 show the construction of the large frames. The lower wooden portion on which the tracings rest is padded with cotton [illegible] which is laid a piece of heavy carpet. A system of levers and counterweights balance the wooden frame in any position. This frame as well as the iron frame which holds the glass are hinged at the outer end. At the inner end the iron frame is supported by springs, which prevent shocks, and which stop the motion of the iron frame and glass at a certain point and allow the lower wooden frame to drop away from the glass and free the tracing.

The method of operating the frames is as follows: The tracing and blue print paper are placed on the carpet and the wooden frame is then raised by the handles until the glass and iron frame are reached. At this point the two frames are nearly parallel, and as the motion is continued the glass and iron frames are lifted clear of their supports and their entire weight is thrown upon the tracing. If the lower frame is properly padded the contact is perfect. In good light the twelve frames will turn out a print every minute. For small prints of sketches, etc., which are wanted in a hurry regular photographer's paper is used.

Fig. 2 shows the interior of the gallery. At the farther end there is a case of drawers for holding tracings and prints and at two convenient points boxes are fastened to the wall. These boxes contain roll print paper. At the lower edge of the lid there is a cleat and slot for cutting paper accurately and quickly to any desired size. Near the middle of the gallery, on the right, there can be seen a large window. Outside this there is a hoist for raising roll paper and heavy supplies to the store room on the fourth floor.

At the end of the gallery is the drying and preparing room. There are two large tanks at one corner of the room. Over these tanks and extending the full length of one side of the room, are rows of copper wire for hanging up freshly prepared paper, and for drying prints. The firm prepares most of the paper used, a small amount of special paper for quick printing only being bought already prepared. At the side of the dark room opposite the tanks there are racks for filing away prints which are returned from the shops to be used again on future contracts, and also for filing any extra prints which may be taken. A dumb-waiter and speaking tubes connect the second and third floor drafting offices with the blue print room. There is a boy on each floor to attend to the sending and receiving of prints and tracings.

Adjoining the gallery and preparing room there is a large dark closet for the use of the photographer. In this closet there is a tank for running water and all the appliances of a photographer's dark room. All the rooms are lighted by electric lights and heated by hot air. In the preparing room there are large tables for trimming and sorting prints, etc.

The entire arrangement described is very com-

plete and conveniently arranged and we are informed that it is giving very satisfactory results. We are indebted for the information from which the description has been prepared to Mr. Chas. H. Wright, M. Am. Soc. C. E., Chief Engineer of the Brown Hoisting & Conveying Machine Co.

## THE SILTING-UP OF LAKE McDONALD AND THE LEAK AT THE AUSTIN DAM.*

By Thomas U. Taylor, Assoc. M. Am. Soc. C. E.†

### Silting.

In 1890 cross-sections of the Colorado River were taken at 16 different stations, as shown in the following tabular statement, and in Fig. 1. The complete outline of the diagrams in Fig. 1 represents the original cross-section, where the horizontal line is the water surface, even with the crest of the dam, and the shaded area shows the amount of silt that has been deposited up to date. All vertical dimensions are magnified ten times. The cross-sections were repeated in May, 1897, for the U. S. Geological Survey, and again in January, 1900.

The water first flowed over the crest of the dam in May, 1893, and there was at this time 83,556,000 cu. yds. of water in the main channel of the lake up to the level of the crest of the dam, and in 1897, 51,889,000 cu. yds., leaving 31,667,000 cu. yds. of silt, amounting to 38% of the original capacity. If these volumes are estimated in depths on a square mile base, we have in 1893 a volume of water equal to a depth of 80.9 ft., and in 1897 a depth of 50 ft. of water and 30.9 ft. of silt. This was the result from May, 1893, to May, 1897, a period of four years. The amount deposited per year is thus 7.7 ft. on a square mile base.

The accompanying table shows the maximum and mean depths of water for 1893 and 1900, the maximum and mean depths of silt for 1900, and the percentage of silting up at the respective stations:

Depths of Water and Silt in the Reservoir Formed by the Great Dam at Austin, Tex.

| Station mls frm dam. | Depth—Maximum—Water, ft. 1893. | Maximum—Water, ft. 1900. | Maximum—Silt, ft. 1900. | Mean—Water, ft. 1893. | Mean—Water, ft. 1900. | Mean—Silt, ft. 1900. | Amount of filling up, p. ct. of total. |
|---|---|---|---|---|---|---|---|
| 0.0 | 66.0 | 39.0 | 27.0 | 40.1 | 27.5 | 12.6 | 31.2 |
| 0.2 | 65.7 | 38.0 | 27.7 | 37.6 | 26.5 | 11.1 | 32.2 |
| 1.2 | 63.8 | 35.5 | 28.3 | 30.6 | 21.7 | 8.9 | 30.2 |
| 3.0 | 56.0 | 31.5 | 24.5 | 33.4 | 21.5 | 11.9 | 38.8 |
| 4.0 | 47.8 | 31.5 | 19.0 | 38.0 | 23.5 | 14.5 | 37.9 |
| 5.6 | 47.5 | 27.5 | 23.0 | 36.7 | 23.0 | 13.7 | 42.0 |
| 7.0 | 47.0 | 22.0 | 26.0 | 36.3 | 17.4 | 18.9 | 56.3 |
| 7.8 | 44.8 | 20.5 | 25.0 | 30.7 | 15.4 | 15.3 | 56.3 |
| 9.3 | 40.4 | 13.4 | 29.0 | 30.8 | 10.2 | 20.6 | 66.9 |
| 10.4 | 40.9 | 13.5 | 27.4 | 27.2 | 7.9 | 19.3 | 71.8 |
| 13.7 | 29.4 | 9.8 | 26.0 | 20.3 | 5.5 | 14.8 | 78.9 |
| 14.6 | 24.0 | 12.5 | 16.0 | 17.2 | 9.0 | 8.2 | 50.4 |
| 15.9 | 16.6 | 12.0 | 15.0 | 13.2 | 10.0 | 3.2 | 60.0 |
| 17.4 | 13.2 | 9.5 | 7.0 | 11.2 | 8.8 | 2.4 | 30.0 |
| 18.9 | 7.6 | 5.0 | 2.6 | 5.6 | 3.9 | 1.7 | 33.0 |
| 20.0 | 3.7 | 2.2 | 1.5 | 2.8 | 2.0 | 1.8 | 35.0 |

The maximum depth of silt is not always equal to the differences of the maximum depths of water for 1893 and 1900, as the channel has shifted at several points. This is very noticeable at Sta. 13.7, known as Santa Monica (or Sulphur) Springs. The column of per cents. is that ratio that the present cross-section of silt bears to the original cross-section of water. Thus at Santa Monica Springs (13.7) 78.9% of the original cross-section has filled up.

There are now (February, 1900), beneath the level of the top of the dam 43,460,000 cu. yds. of water in the main channel of the lake, or 42.1 ft. on a square mile base, and 38.8 ft. of silt. Thus 48% of the original storage capacity of the lake

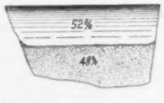



Fig. 2.—Typical Cross-Section for the Whole Lake.

is now mud. The rate of deposit up to date on a square mile base is 5.8 ft. per year.

This silt, to within a couple of miles of the head of the lake, was in 1897 a fine impalpable absolutely gritless deposit. At the head and for about two miles down the lake the silt consisted of sand which readily deposited when the velocity of the stream was checked by the waters of the lake. At occasional points below the head of the lake, small bars of sand were found near the mouths of small canyons or creeks.

From Mar. 15 to Apr. 17, 1899, the water level of the lake was a little over 10 ft. below the crest of the dam. The water commenced again flowing over the crest of the dam on Apr. 21 and continued to do so at small depths until June 7, when the river rose to a height of 9.8 ft. above the crest of the dam. This flood continued to June 12, and its result on the cross-sections near the head of the lake was marked. The sections at Stas. 14.6, 15.9, 17.4, 18.9 were scoured out 2 to 3 ft. deeper than the sections of 1897, and at Sta. 15.9 a sandbar was deposited on the inside (left) of the curve of

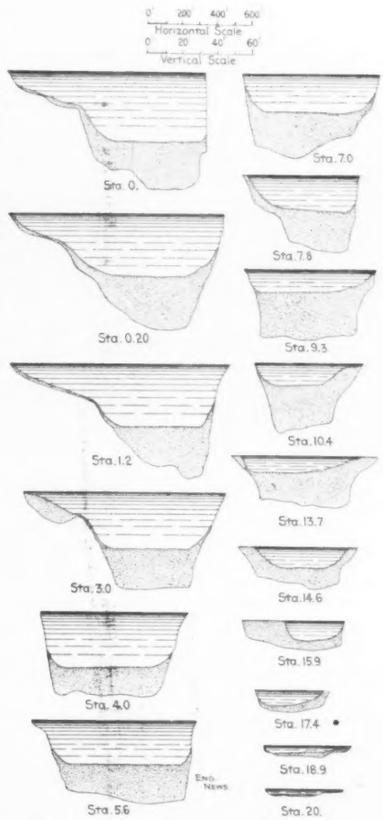



Fig. 1.—Cross-Sections Illustrating the Silting Up of Lake McDonald Formed by the Great Dam at Austin, Tex.
(Station numbers indicate distance, in miles, from dam.)

the river, contracting the channel to less than half its former width.

The typical section illustrating the ratio of silt and water areas for the whole lake is about midway between Stas. 5.6 and 7.0; i. e., about ¼ of a mile below the Chatauqua wharf. Fig. 2 illustrates this section, in which, as in the diagrams of Fig. 1, the vertical scale is magnified ten times.

Fig. 3 (taken from a report made to the U. S. Geological Survey in 1897), shows the configuration and geography of the Colorado River. The river for two or three hundred miles flows through a hilly country from above Colorado City, on the Texas Pacific R. R., and absorbs in its course the waters of the Concho, the San Saba, the Llano, and those of Pecan Bayou. All the country drained by these tributaries is hilly, with the exception of a few miles along the head of the Colorado and the Concho.

### Theory of Silting-up of Lake McDonald.

The silting-up of reservoirs for purposes of comparison is best reduced to heights or depths on a square mile base. To derive an expression for the amount of silt deposited in a given time, let x = depth (in feet) of silt deposited by each foot in height per year; h = original depth of water in reservoir. The depths of silt at end of 1, 2, 3, n years are:

1 year, h x.

2 years, $h\,x + x\,(h - h\,x) = 2\,h\,x - h\,x^2$.

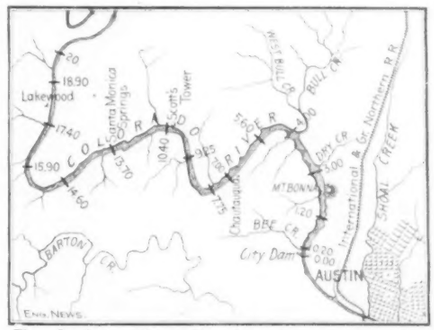



Fig. 3.—Index Map Showing Sounding Stations Across Lake McDonald, Above Austin, Tex.
(Figures at stations indicate distance, in miles, from dam.)

3 years, $(2\,h\,x - h\,x^2)\,(1 - x) = 3\,h\,x - 3\,h\,x^2 + h\,x^3$.

4 years, $(3\,h\,x - 3\,h\,x^2 + h\,x^3)\,(1 - x) = 4\,h\,x - 6\,h\,x^2 + 4\,h\,x^3 - h\,x^4$.

That is,

1. h x.
2. h [1 — (1 — x)²].
3. h [1 — (1 — x)³].
4. h [1 — (1 — x)⁴].

Hence, if we let d = amount deposited in n years, we have, d = h [1 — (1 — x) n].

Now in 1897, h = 81, d = 31, n = 4; ∴ x = .1135.

In 1900, we had d = .48 h, n = 6⅔,

$$\therefore\ 1 - (1 - x)^{\frac{20}{3}} = .48;$$

$$(1 - x)^{\frac{20}{3}} = .52,\quad \therefore\ x = .09343.$$

For safety let us assume the least value of x. The following table will give the results for each year on this assumption:

| Year. | Amount silt. | Year. | Amount silt. | Year. | Amount silt. | Year. | Amount silt. |
|---|---|---|---|---|---|---|---|
| 1 | 0.093 | 6⅔ | 0.480 | 12 | 0.692 | 18 | 0.829 |
| 2 | .178 | 7 | .497 | 13 | .721 | 19 | .845 |
| 3 | .255 | 8 | .568 | 14 | .747 | 20 | .860 |
| 4 | .325 | 9 | .586 | 15 | .770 | 25 | .914 |
| 5 | .388 | 10 | .625 | 16 | .792 | 30 | .947 |
| 6 | .445 | 11 | .660 | 17 | .811 | 40 | .980 |

These results will not be true for any reservoir in which there is an appreciable current acting on the bottom of basin; i. e., on the upper surface of the silt. In Lake McDonald the lake level can sink to 10 ft. below the crest of the dam and still have a fair current in the penstocks, as the bottom of the forebay is at present 12 ft. below

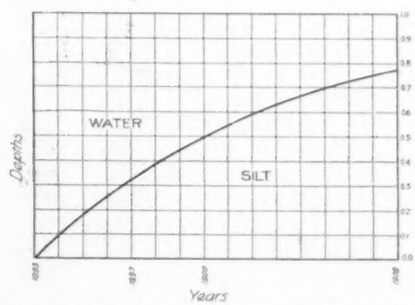



Fig. 4.—Curve Illustrating Progress of Silting Up in Lake McDonald.

the crest. When this condition obtains, as it did during the months of March, April and October, 1899, there is a current on the upper third of the lake. Unless the lake is drained by the three 3-ft. pipes at the west end of the dam, which has not occurred since 1893, it is not possible for the current under ordinary conditions to affect the silt in the lower two-thirds of the lake.

*The Austin dam and the breaks in the structure were described in Engineering News of July 11, 1891; Nov. 10, 1892; Jan. 26, June 8, June 29, July 27, Aug. 3, Sept. 28, and Oct. 19, 1893; Jan. 25, June, and Aug. 2, 1894.—Ed.

†Professor of Civil Engineering, University of Texas, Austin, Tex.

The results of the table are illustrated graphically in Fig. 4.

### The Leak in the Dam.

In May, 1893, the water from the lake cut under the east bulkhead and undermined the proposed power-house foundation. The bulkhead cracked at a point about 40 ft. from the east end of the dam, along the line HM, in Fig. 5, and settled down at its east end. The proposed foundation was utterly wrecked. The water was soon cut off from the forebay by a dam composed of timber, hay and earth. The masonry of the deranged part of the bulkhead was then removed, after which it was rebuilt and extended by a concrete wall 8 and 5 ft. wide, 112 ft. long, carried to a depth of 57 ft. below the crest of the dam. It was thought that this would cut off the leak on the dangerous portion. In excavating for this extension wall, alternate layers of hard and soft limestone were encountered. The bottom layer of the concrete filling HK, was laid on one of these hard strata, but it was fully demonstrated that a current of water was running underneath. Several holes were drilled and the water welled up through these holes in jets several inches high. However it was thought safe to plug these up and ignore the stream below. The bulkhead masonry originally extended to a level RS, 36 ft. below the top of the dam; but as an extra precaution a tunnel 6 × 6 ft. square was cut under the bulkhead masonry back to the end of the dam proper and the space filled with concrete. The space below the 42-ft. level under the tunnel was not disturbed.

The foundation for the power-house was then excavated to a depth of over 60 ft. below the crest of the dam. The original contractors, owing to a disagreement in regard to the excess of water flooding their work, surrendered their contract. The next contractors succeeded in controlling this water by use of a cement chamber at D, Fig. 5, and a 10-in. horizontal pipe which projects from the wall of the power-house at the point C, about 55 ft. below the crest of the dam. This is often referred to as the "spring." Measurements taken in October, 1895, showed a range (on the horizontal surface of water in the tail-race) of 5.1 ft., and a fall of 5.8 ft., giving a discharge of 4.6 ft. per sec. A 3,000,000-gallon pump entirely exhausted this "spring." In May, 1897, the flow from the so-called "spring" suddenly increased. An average of several measurements gave a range of 11 ft. and a fall of 5.8 ft., and therefore a discharge of about 10 sec. ft. Measurements recently taken give a range of 8.8 ft. and a fall of 5.8 ft., and therefore a discharge of 8.0 sec. ft.

In the spring of 1899 it was discovered from the behavior of drift, that water was disappearing from the lake at a point A, Fig. 5. This source of leakage was stopped by filling in the lake at this point with clay, loose and in bags. While the operation of filling in was going on the water from the 10-in. pipe almost ceased for a few hours, but

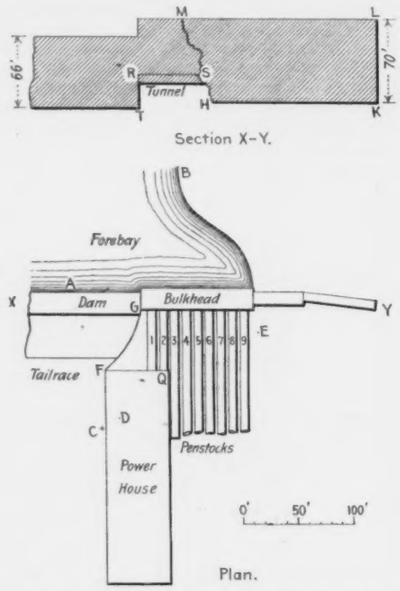



Fig. 5.—Plan and Section Showing Leaks at Austin Dam.

soon reached its normal amount. The filling kept the water discolored and muddy.

In the fall of 1899 it was noticed that water was disappearing at a point B, Fig. 5, only a few feet from the shore. A cofferdam of sheet-piling was constructed around this point, and it was filled up with hay and earth. In the latter part of December, 1899, the earth in front of and between the power-house and bulkhead began to sink, and this continued to such an extent that it was determined to remove the earth covering the 9-ft. penstocks under the sunken areas in order to discover the cause. The removal of the earth showed that penstock No. 3, Fig. 5, was buckled, and that it had sunk about 20 ins. at one place. A cold stream of water of at least 2 sec. ft. capacity and 16 ft. below top of dam, was found when the earth was taken out between the power-house and penstock, No. 3, and between penstocks Nos. 3 and 4. This seemed to come from the direction of the point E. The stream of water was partly deflected around the north end of the power-house and under penstocks Nos. 1 and 2. The water had not risen in the excavation, and it is discharged through some 2-in. pipes at F, 14 ft. below the crest of the dam, through two or three other small pipes and through absorption through the wing wall, G, and through the power-house wall, PQ. Penstock No. 5 was also found buckled at a point about 35 ft. from the bulkhead. The bucklings of these pipes was caused by their settling. The source of the water in the ditches has just been located (about Feb. 11, 1900.—Ed.). It comes from a broken 3-in. pipe, tapped into the bottom of penstock No. 5. It broke at an elbow just below the penstock, at a point about 16 ft. below the crest of the dam.

## STREET CLEANING STATISTICS FOR FORTY AMERICAN CITIES.

Through the courtesy of Mr. Andrew Rosewater, M. Am. Soc. C. E., City Engineer of Omaha, Neb., we are enabled to present the accompanying table of street cleaning statistics for the year 1899. The figures of cost are said to be estimated, but in most cases are probably quite close, while they are generally supplemented by the actual figures for the year 1898.

The figures should be taken in the spirit with which they were doubtless compiled, as shedding some light on the street cleaning problem, rather than telling the whole story for each city. A number of factors are necessarily left out of account, notably the frequency of sweeping and the character of the paving material. A few street cleaning figures for some 80 of the largest cities of the United States are given in Bulletin 24, "Statistics of Cities," U. S. Department of Labor. Only the number of yards swept per week and a statement as to whether hand or machine labor is used, are reported under street cleaning in the bulletin named, but in another table the number of miles of each class of pavement is stated.

STREET CLEANING STATISTICS (1899) FOR FORTY AMERICAN CITIES.

Compiled from Official Data Obtained in January, 1900, by Andrew Rosewater, M. Am. Soc. C. E., City Engineer of Omaha, Neb.

| Cities. | Population. | Approximate sq. yds. of paving in city. | Paved streets, miles. | Expenditures for street cleaning. Actual, 1898. | Estimated 1899. | Cost of cleaning paved streets.† Per mile. | Per 1,000 pop. | Per sq. yd. | Are machines used? | Is work done by contract? | Sprinkling.—Do you sweeping? | If so, how is work done? | Are dustbins pl'c'd on sts? | ‡What scale of wages is paid for men and teams? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New York, N. Y. | 3,550,000 | 30,423,800 | 1,396 | $4,258,707 | $5,476,088 | $3,924.10 | $1,542.54 | $179.99 | Partly. | No. | Yes. | City. | No. | Men, $722⅝; team, $3.50 |
| Chicago, Ill. | 1,351,000 | ..... | 1,248 | 675,000 | ..... | 540.87 | 499.62 | ..... | ..... | .... | .... | ..... | .... | ..... |
| Philadelphia, Pa. | 1,250,000 | ..... | 850 | 545,451 | 510,722 | 600.85 | 408.58 | ..... | Yes. | Yes. | Yes. | Contract. | No. | ..... |
| St. Louis, Mo. | 630,000 | 3,783,428 | 422 | 220,856 | 245,000 | 580.57 | 388.88 | 64.75 | Yes. | Yes. | Yes. | Contract. | No. | Men, $1.50; [6]team, $3.75 |
| Baltimore, Md. | 600,000 | 11,750,755 | 388 | 380,928 | 375,286 | 967.48 | 625.44 | 31.93 | Yes. | No. | Yes. | City. | No. | Men, $1.66⅔; team, 3.25 |
| Boston, Mass. | 500,000 | 8,981,828 | 479 | 315,064 | 320,000 | 667.40 | 640.00 | 35.62 | Yes. | No. | Yes. | City. | No. | Men, 2.00; team, 4.12 |
| Buffalo, N. Y. | 400,000 | 6,247,401 | 330 | 137,976 | 150,000 | 454.54 | 375.00 | 24.01 | Yes. | Yes | Yes. | Contract. | Yes[7] | Men, 1.50; team, 4.00 |
| Cleveland, O. | 400,000 | 3,422,222 | 170 | 650,000 | 55,000 | 323.53 | 137.50 | 16.07 | Yes. | Yes. | Yes. | Contract. | No. | Men, 1.30; team, 3.50 |
| Detroit, Mich. | 347,000 | 4,940,000 | 268 | 130,000 | 144,500 | 539.14 | 416.42 | 29.25 | Yes. | No. | Yes. | City. | Yes[7] | Men, 1.50; team, 3.50 |
| Pittsburg, Pa. | 300,000 | ..... | 219 | 137,821 | 163,499 | 747.40 | 545.00 | ..... | Yes. | No. | Yes. | City. | Yes[7] | Men, 1.50; t'm city prop. |
| Washington, D. C. | 287,000 | 4,623,076 | 206 | 177,000 | 145,000 | 702.30 | 504.41 | 31.36 | Both. | Yes | Yes. | Contract. | No. | Men, 1.75; team, $3.50 |
| Milwaukee, Wis. | 280,000 | 1,760,000 | 75 | 98,223 | 103,371 | 1,378.27 | 369.18 | 58.73 | Yes. | Yes. | Yes. | Contract. | No. | Men, 1.50; team, 3.50 |
| Newark N. J. | 250,000 | 2,155,700 | 102 | 37,511 | ..... | 367.50 | 150.04 | 17.40 | Yes. | Yes. | Yes. | Contract. | No. | Men, 17cts.; team, 48½cts. |
| Minneapolis, Minn. | 255,000 | 1,574,649 | 90 | 41,681 | ..... | 419.28 | 185.24 | 26.47 | Yes. | No, | Yes. | City. | Yes[7] | Men, $1.75; team, $3.00 |
| Jersey City, N. J. | 210,000 | 1,793,333 | 100. | 28,000 | 33,000 | 330.00 | 157.14 | 18.40 | Yes. | Yes. | Yes. | Contract. | No. | Men, 1.35; |
| Indianapolis, Ind. | 200,000 | 1,786,629 | 82 | 52,657 | 46,500 | 569.30 | 232.50 | 29.52 | Yes. | Yes. | Yes. | Contract. | No. | Men, 1.40; team, 3.00 |
| St. Paul, Minn. | 175,000 | 1,000,000 | 45 | 30,000 | 34,000 | 755.55 | 194.29 | 34.00 | Yes. | No. | Yes. | City. | Yes[7] | Men, 1.50; team, 3.00 |
| Kansas City, Mo. | 175,000 | 3,000,000 | 170 | 31,000 | 35,000 | 205.88 | 200.00 | 11.67 | Yes. | No. | Yes. | City. | Yes[7] | Men, 1.75; team, 3.00 |
| Denver, Colo. | 165,000 | 530,000 | 19 | 25,000 | 27,800 | 1,430.77 | 168.48 | 52.45 | Yes. | No. | Yes. | City. | Yes[7] | Men, 2.00; team, 3.00 |
| Omaha, Neb. | 150,000 | 1,954,416 | 83 | 23,142 | 18,716* | 226.86 | 124.77 | 9.57 | No. | No. | No. | ..... | No. | Men, 1.50; team, 3.00 |
| Toledo, O | 150,000 | 1,896,292 | 125 | 9,468 | 10,024 | 80.32 | 66.83 | 5.28 | Yes. | Yes. | Yes. | City. | No. | Men, 1.50; team, 3.00 |
| Syracuse, N. Y. | 125,000 | 793,000 | 36 | 40,776 | 72,485 | 1,995.18 | 579.88 | 9.14 | Yes. | No. | Yes. | City. | No. | Men, 1.50; team, 3.50 |
| Allegheny, Pa. | 125,000 | 1,500,000 | 83 | 29,267 | 35,000 | 424.24 | 280.00 | 23.33 | Yes. | No. | Yes. | City. | No. | Men, 1.50; |
| Columbus, O. | 121,000 | 2,160,468 | 116 | 27,923 | 64,000 | 550.67 | 528.93 | 29.62 | Yes. | Yes. | Yes. | Contract. | No. | Men, 1.50; team, 3.00 |
| Los Angeles, Cal. | 115,000 | 530,000 | 18 | ..... | 27,953 | 1,552.36 | 243.06 | 52.74 | Yes. | Yes. | Yes. | Contract. | Yes[7] | Men, 2.00; team, 3.50 |
| Worcester, Mass. | 114,000 | 237,454 | 11 | 11,000 | 11,444 | 1,022.70 | 100.39 | 48.19 | Partly. | No. | Yes. | City. | No. | Men, 1.75; teams.[8] |
| Paterson, N. J. | 110,000 | 1,028,000 | 58 | ..... | ..... | ..... | ..... | ..... | Yes. | No. | Yes. | City. | .... | Men, 1.50; team, 4.00 |
| Richmond, Va. | 100,000 | 350,000 | 22 | 48,151 | 56,500 | 2,568.18 | 565.00 | 161.43 | Yes. | No. | Yes. | City. | No. | Men, 1.50; |
| Albany, N. Y. | 100,000 | 1,419,545 | 81 | 41,000 | 41,000 | 508.68 | 410.00 | 28.88 | Yes. | No. | Yes. | City. | No. | Men, 1.50; team, 2.00 |
| Grand Rapids, Mich. | 90,000 | ..... | 20 | ..... | ..... | ..... | ..... | ..... | Yes. | No. | Yes. | City. | Yes. | Men, 1.75; team, 3.50 |
| Lowell, Mass. | 89,000 | 336,500 | 17 | 20,384 | 20,384 | 1,181,66 | 224.96 | 60.58 | Yes. | No. | Yes. | City. | No. | Men, 1.75; team, 2.00 |
| Dayton, O. | 85,000 | 709,820 | 29 | 31,065 | 30,000 | 1,030.22 | 352.94 | 42.26 | No. | No. | No. | ..... | No. | Men, 1.50; team, 3.50 |
| Hartford, Conn. | 77,000 | 200,600 | 8 | ..... | ..... | ..... | ..... | ..... | Yes. | No. | Yes. | City. | Yes[7] | ..... |
| St. Joseph, Mo. | 75,000 | 950,000 | 45 | 9,000 | 9,000 | 200.00 | 120.00 | 9.41 | Yes. | No. | Yes. | City. | No. | Men, 1.50; team, 2.75 |
| Lynn, Mass. | 70,000 | 75,000 | 3 | 5,300 | 6,300 | 2,016.00 | 90.00 | 84.00 | Yes. | No. | No. | ..... | No. | Men, 2.00; |
| Troy, N. Y. | 68,000 | 605,000 | 36 | ..... | ..... | ..... | ..... | ..... | No. | No. | Yes. | Contract. | No. | ..... |
| Trenton, N. J. | 66,000 | 381,271 | 18 | 9,000 | 9,000 | 500.00 | 136.36 | 23.57 | Yes. | No. | Yes. | City. | Yes[7] | Men, 1.50; team, 4.00 |
| Charleston, S. C. | 65,000 | ..... | 33 | 12,000 | 12,000 | 363.68 | 184.61 | ..... | Yes. | No. | Yes. | City. | No. | Men, 1.25; |
| Evansville, Ind. | 65,000 | 688,533 | 25 | 75,000 | 95,000 | 3,800.00 | 1,461.54 | 137.97 | Yes. | Yes. | Yes. | Contract. | No. | ..... |
| Salt Lake City, Utah. | 60,000 | 107,771 | 3 | 3,909 | 5,440 | 2,014.81 | 90.07 | 50.47 | Yes. | No. | Yes. | City. | No. | Men, 1.75; team, 3.00 |

*Includes $2,000 for removal of snow and ice. †Assuming that all paved streets in each city are cleaned. [5]Per annum. [6]Also for horsecart, $2.50. [7]To the question: "Is the practice satisfactory?" these places replied, "Yes;" others made no reply. [8]Single team, $3.00; double, $4.00.

‡Cleveland reported that 9 hours constituted a day's work; 8 hours was reported for Buffalo, Detroit, Pittsburg, Omaha, Allegheny, Los Angeles, Albany, and St. Joseph; the other places did not report.